COLORADO IRON WORKS COMPANY

ORE SMELTING EQUIPMENTS

ORE MILLING MACHINERY

CATALOGUE NO. 10 C

ADVANCED CYANIDE PRACTICE AND EQUIPMENT

1860 1912

DENVER, COLORADO.

U.S.A.

Catalogue No. 10-C.

Advanced Cyanide Practice and Equipment

Being a Brief Description of the Cyanide Process and of Equipment Used Therein

Colorado Iron Works Co.

Denver, Colorado, U. S. A.

Private Exchange Telephone, Main 3380

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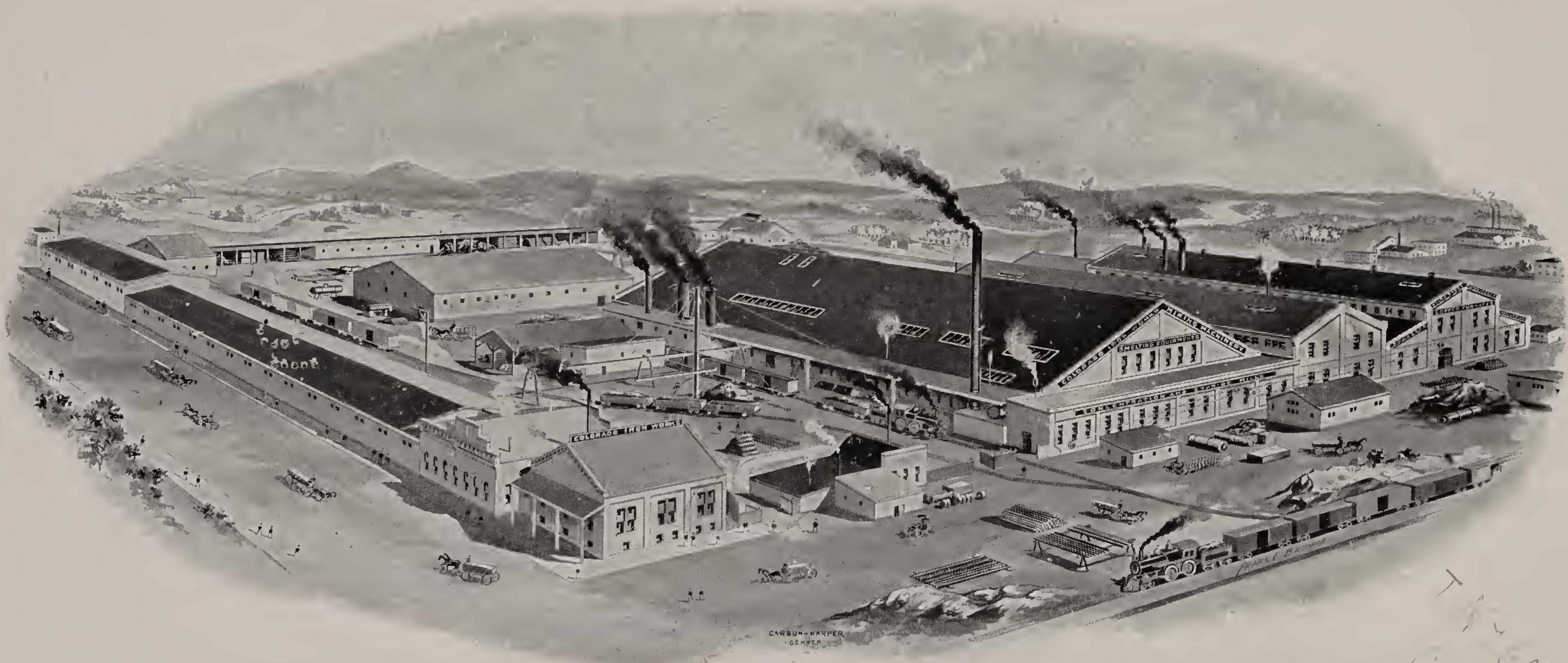


PLANT OF COLORADO IRON WORKS COMPANY.

ANNOUNCEMENT.

The purpose of this book is to acquaint our friends and the public with certain machinery which we build for use in cyaniding ores. The equipment shown is limited to that having special interest to cyanide process operators, and we shall issue a separate catalogue covering crushing, screening and other machinery of general application in all processes of ore reduction. The catalogue is preceded by a short description of the cyanide process, which it is hoped will prove useful to those who are not informed in its theory and application.

In many cases cyanidation is combined with amalgamation or concentration, or both. On each of these processes we issue a separate catalogue, as well as one on smelting; any of which will be mailed on application.

A great many plans of mills and smelters are on file in our engineering department, which will prove of great service to those planning the erection of ore treatment plants, and we employ a large corps of engineers and metallurgists of wide experience, whose assistance is at their command. No charge is made for ordinary service of this kind, but, where expense is involved, the work will not be undertaken without a previous understanding.

We design and equip plants for the reduction of ores by all modern processes and in addition we will engage to erect them complete, demonstrating their efficiency in practical operation.

We endeavor to have our illustrations correctly represent the various machinery, but in the advance which is continually being made in efforts to improve it, changes in detail are made from time to time. As these are in the interest of the purchaser, we feel that an apology on this account is perhaps superfluous.

Our aim has always been the production of a high-grade line of machinery, the prices being made as low as consistent with high quality. In no case do we attempt to build a machine to come within a certain price and place it in the field of competition with others having low first cost as their chief merit. It is this policy, consistently maintained for fifty years, that has established our enviable reputation.

COLORADO IRON WORKS COMPANY.

REPAIR WORK.

We desire to call particular attention to the promptness with which repairs and renewals can be made at our works. Our foundry and machine shops are ample and no delays need be anticipated.

Our advantages are apparent to our milling friends in the Rocky Mountains, as from three to fourteen days are saved in procuring supplies from Denver direct. We have telephone connection with nearly all mining camps in Colorado and adjoining States, and preference is always given renewal orders, as we fully realize the importance of keeping a mill running.

In ordering repairs be very specific and give numbers where possible. Make measurements carefully, and when possible give a rough sketch, no matter how crude. Where practicable refer to catalogue number for details, etc.

TERMS.

Our terms to regular customers with established credit are monthly settlements. On new business, for equipment only, one-third to one-half cash with order, balance when ready for shipment. On new business, for equipment and erection, one-third to one-half cash with order with special arrangements as to payment of the balance. On special work done to order, cash in advance or part cash in advance and an ample guarantee to secure payment of the balance.

Remittances should be in Denver or New York funds or their equivalent. We pay no exchange.

SHIPPING DIRECTIONS.

Shipping directions should be explicit and state whether by freight or express. If not otherwise instructed, all material will be shipped by freight, except light packages, which will be forwarded by express.

Our responsibility ceases with delivery to the carrier in good order. In the event of loss or damage in transit, the agent of the carrier should be immediately notified. We will render all assistance possible in adjusting the claims of our customers for losses, damage and excess charges.

The Cyanide Process.

The solubility of gold in solutions of the alkali cyanides had long been known; but as the experiments had been with comparatively strong solutions, the facts were of only scientific interest, as it seemed that the cost, instability and poisonous properties of the cyanides would prevent their use in a process of extraction from ores. It was comparatively recently that attention was directed to the application of potassium cyanide direct to gold ores and, as is usually the case with new processes, the methods proposed were more complicated than were later found to be best.

After it had been demonstrated that gold in ores could economically be brought into solution as a double cyanide of gold and potassium, an efficient means of precipitation was still lacking to complete a working process. A number of investigators deserve great credit for early work in this line, but for the cyanide process as we know it today the world is indebted to J. S. MacArthur, R. W. Forrest and W. Forrest. These men carried out a very exhaustive series of researches, as a result of which they presented a complete and acceptable working process, one of the most important features of which was the recovery by precipitation with zinc shavings. A discovery made by them, and for which much was claimed, was that a very weak solution of potassium cyanide exhibited a selective action, by which the gold and silver went into solution and the base metals remained unaffected. Considerations affecting the time of treatment and general economy of actual operation prevent the use of solutions of such strength as to take full advantage of this property, but the interference from objectionable constituents is slight notwithstanding; much less, for example, than the effect of such compounds in the application of the chlorination process.

The work of MacArthur and the Forrests was so thorough and complete from a technical standpoint that it may fairly be said that the improvements which were made during many years subsequent to the time when their process was first introduced on the Rand in 1891, have been very largely of a mechanical and engineering nature. It must not be inferred from this that the art is remaining stationary. This is very far from the case as the advancements made in

methods of handling the material and in the control of the process have made it much more attractive than it was even two or three years ago. The present tendency is toward the development of continuous treatment methods with the elimination of all manual labor and the removal, to a large degree, of "the personal equation". The ultimate goal is the attainment of a practically automatic, continuous method, using the principle of counter-currents in which the flow of the solution is contrary to the flow of the ore; and this may be said to be now at hand.

It is agreed that the gold goes into solution as a double cyanide of gold and potassium, in the form expressed by $AuK(CN)_2$, and although some authorities have disputed the necessity of the presence of oxygen, it is almost universally admitted that oxygen or an oxidizing agent is essential. Conversely, reducing agents exert an injurious action, and their presence is to be avoided as far as possible. For these reasons it is attempted in practice to secure a thorough oxygenation during treatment and to avoid the unnecessary formation of compounds having a reducing action as well ás to add suitable reagents to counteract their effect when unavoidably present to such an extent as excessively to destroy cyanide.

The selective action of cyanide solutions is at its maximum in solutions of greater dilution than are found most economical in regular working, but, fortunately, great solvent effect is exerted by small concentrations and the cost of cyanide per ton of ore treated is therefore low.

The more important early applications of the cyanide process on a large scale were to the treatment of accumulations of tailings, from which it was readily extended to tailings from the current production of mills. The process has now, however, taken a place in the very front rank for direct application to ores, although in many cases in connection with amalgamation or concentration. The ores amenable to cyanidation are of very common occurrence, and with by far the greater number no preparation, other than crushing, is required. The exceptions are telluride and sulphide ores, either in which the precious metals are not soluble in cyanide solutions or in which the deleterious action of the objectionable constituents would cause a too great loss of cyanide. The remedy is preliminary roasting, or treatment in the wet way by means of oxidizing agents applied in solu-

tion. Owing to the excessive cost of roasting, the chemical oxidation of such ores has recently been given great attention and the entire satisfaction with which such treatment is being carried out in a number of recently completed plants has demonstrated the success of the method and warrants its general acceptance. Concentration is often advantageously combined with such a method, as by this means the greater part of the sulphides is removed, the small portion remaining being economically treated by oxidizing agents in solution and a shipping product of concentrates being obtained as well.

During the last few years the use of the cyanide process has been extended to purely silver ores, many of which are now treated entirely by cyanidation with a greater saving than possible by any other method. The process for silver ores is essentially the same as for gold ores, the principal difference being in the increased time required for solution of the silver. The purpose in hand will therefore be served by a description of the cyanide process in its application to gold ores, the various steps in which will be outlined in their regular order.

I. Preparation of the Ore.

It is essential that the particles of gold be sufficiently freed from the surrounding gangue for the cyanide solution to reach and dissolve them, but any further comminution is unnecessary and may even be undesirable. The condition of the gold in the ore, therefore, governs the degree of fineness of crushing, and it may be stated here, although it applies with corresponding force to every step in the process, that it is not possible to obtain total extraction; that to recover the last remaining portion of the gold involves a cost far in excess of its value, and that the attempt should be to attain that degree of extraction which, all things considered, will return the greatest profit in dollars and cents.

Until recently the most economical method consisted in crushing the ore sufficiently to liberate the gold, leaching the coarse sands in tanks and treating the slimes separately. The controlling factor was the expense of treating the slimes, hence the effort was to crush in such a way as to make a minimum of extremely fine material. Improved equipment for agitation, slime thickening and filtration has placed the treatment of slimes on a different basis and they are

not only no longer dreaded, but the newer methods consist in crushing the entire ore to what is practically an all slime product, thereby treating the whole ore by one method. Inasmuch as sand leaching is still used to a large extent and will continue to find application in special cases, it will be well to describe it in some detail.

The degree of fineness used in practice varies from about one-half inch down, with 20 or 30 mesh as common. Machinery of all types used in crushing ores for treatment by other processes finds application in cyanidation, and the same effort is made to reduce all the ore to a certain size without the production of an excessive amount of slimes.

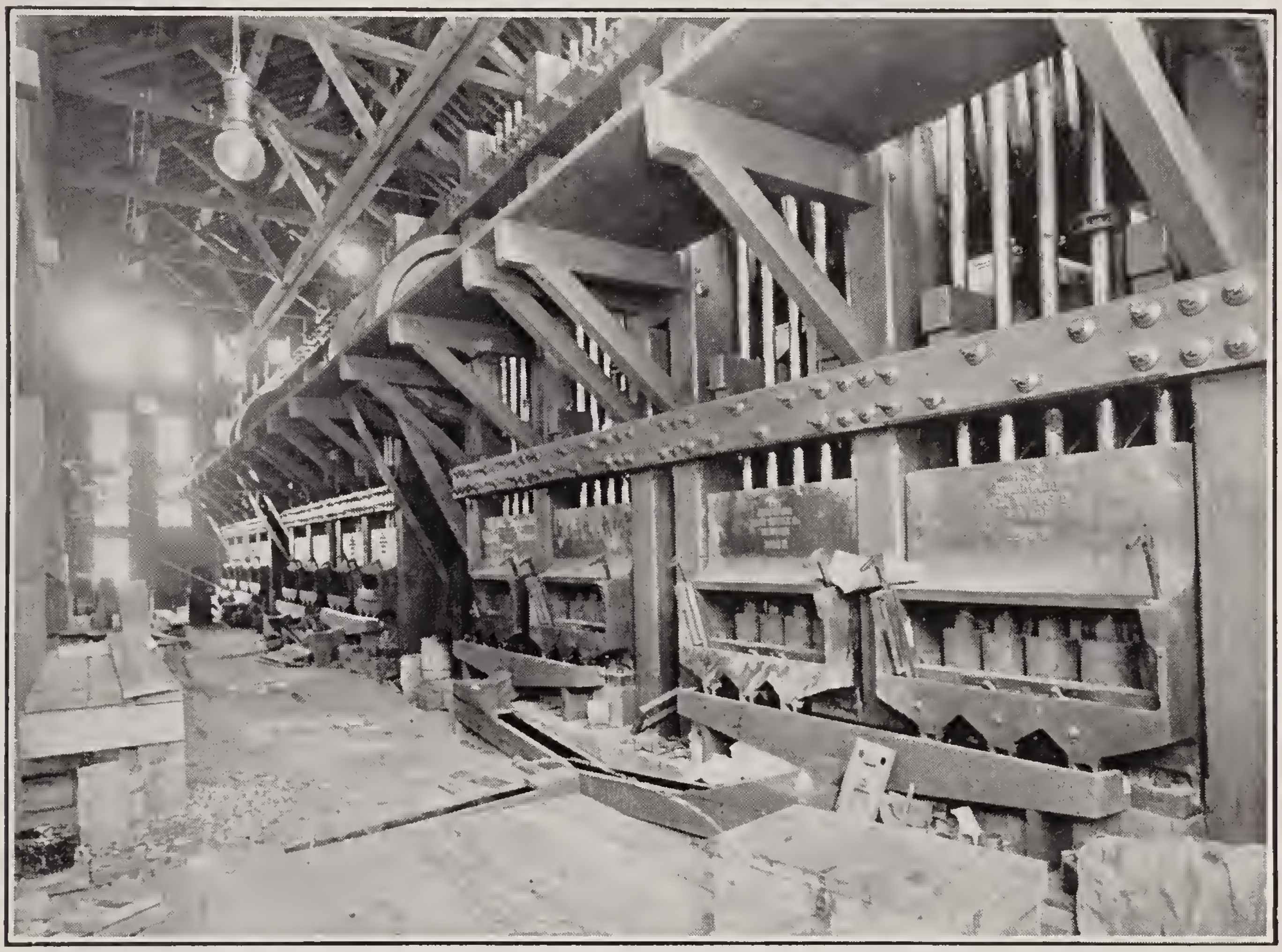
Either wet or dry crushing is adopted, the choice depending upon the nature of the ore. If crushed dry, the cyanide solution comes immediately into intimate contact with the ore, but the soluble acids remain in the ore and cause a loss of cyanide. On the other hand, if crushed wet, the soluble acids are washed out, but there is a dilution of the solution by reason of the moisture retained by the ore and the action of the solution when applied is more or less delayed. Many ores show no difference in cyanide consumption, whether crushed wet or dry, but others if crushed dry consume such an excessive quantity of cyanide that washing must be resorted to before the application of the cyanide solution. It is obvious that ores of this kind should be crushed wet, which will accomplish the washing in the same operation.

In crushing an ore, it is always most economical to make a product containing a proportion of particles larger than the desired maximum and to separate this oversize and return it for recrushing. If an attempt is made to crush all sufficiently fine to at once pass a screen of the desired mesh, a large amount of slimes will be produced and the cost of crushing will be greater. For both wet and dry crushing, the highest type of rolls have no superior. When amalgamation is used, stamps give the best results. For regrinding the product of either rolls or stamps to sizes not economically attained in one operation, use is made of Chilean mills and others of similar type.

For dry crushing, the ore must first be dried, which is a point to be considered, and the relative amount of dust and slimes produced in dry and wet crushing also should influence the choice of

methods. In general the quantity of dust made in dry crushing is less than the amount of slimes produced in crushing the same ore wet, but the assay value of the dust is usually higher than that of the slimes.

The crushed ore should be systematically sampled and an accurate record kept in order to provide a check on extraction. It is



SIXTY-STAMP MILL CRUSHING IN CYANIDE SOLUTION.

only by strict attention to the weight of ore, strength of solution and time of treatment, in connection with assays of the ore, tailings and solutions, that a check can be kept on operations and the extraction improved wherever possible.

II. Dissolution of the Gold and Silver.

Ores vary greatly with respect to their leaching qualities, some, although finely crushed, being more permeable than others less finely reduced. Sands will carry a certain proportion of slimes, if uniformly mixed, and still be suitable for treatment by leaching and percolation and some plants are so fortunate as to handle an ore all of which forms a leachable product, although in most cases it is necessary to separate the slimes for special treatment. When the

attempt is made to leach a pulp containing an excessive amount of slimes, channels will form in it and the solution will follow these comparatively unobstructed paths instead of percolating evenly through the whole mass, thus entirely defeating the purpose of the operation.

The treatment of sands by percolation and leaching is conducted in tanks. The features of these tanks which are special to cyaniding purposes, consist principally in the filter bottoms and gates for discharging the sands after treatment. They may also be provided with automatic devices for filling them with the crushed ore. Minor differences exist in filter bottoms, but the essential features are a grating laid upon the bottom of the tank, a layer of cocoa matting upon the grating and a cover of canvass, the latter being caulked around the periphery of the tank and around the discharge gates with rope. In some cases a layer of clean sand is placed upon the canvas and allowed to remain, a grating being sometimes placed a short distance above the canvas to form a guide in shoveling; but this layer of sand can, of course, only be made use of where tanks are emptied by shoveling, and not where the contents of the tanks are hosed out, which is the usual method in this country.

The solutions are drawn from a pipe entering the tank below the filter bottom, the grating being notched in such a manner as to permit a free flow of the solution to the outlet. Gravity is usually sufficient for percolation, although in some instances a vacuum is maintained below the filter and the operation is sometimes conducted in pressure tanks, although either of these is very exceptional.

The discharge of the sands is through gates in the bottom or doors on the side of the tanks into sluices through which the tailings are run to waste. In some cases, however, the tailings cannot thus easily be disposed of and have to be stacked, involving special equipment for their disposal.

The number of tanks to be supplied for a given capacity depends upon the time required for dissolution. Their depth depends upon the leaching qualities of the pulp to be treated. Experiment will indicate the depth of the column of pulp through which the solution will percolate at a satisfactory rate, three inches per hour being good, and one and one-half inches per hour fair. The depth of the tanks being established in this manner, their diameters are made sufficient

for the required capacity, good practice being to make them of such size that one or a definite number will hold a day's run, thus securing evenness in operation by performing the various steps of filling, emptying, etc., at a certain time each day.

Not only the specific gravity of the pulp, but the manner of charging the tanks greatly influences the capacity in tons of sand. If crushed and charged dry the weight will be fairly constant, as will also be the case if crushed and sized wet and charged direct.

SAND LEACHING TANKS IN CYANIDE PLANT.

If crushed wet, dewatered and charged moist the proportion of weight to bulk will vary between wide limits. Dry pulp is taken to the tanks by cars or conveyors passing over them, dumped, and spread out by hand shoveling. When wet crushed pulp is charged direct, it is led to an automatic distributor which spreads it evenly, and this forms an ideal method of filling.

The tank being filled, the first operation, if charged wet, is to drain it, which is done by opening the valve communicating with the space below the filter bottom. After draining, the solution is run on the top of the charge or is let in below the filter bottom. In the latter case it is usually allowed to rise to the surface of the pulp and

the rest of the solution then added. Practice varies in the way the solution is applied, but as almost any method may be followed without change in the plant, the most suitable one may easily be worked out when the plant is put in operation. The principal variations concern the strength of the various solutions employed and the amount added at one time, as well as the extent to which the washing is carried.

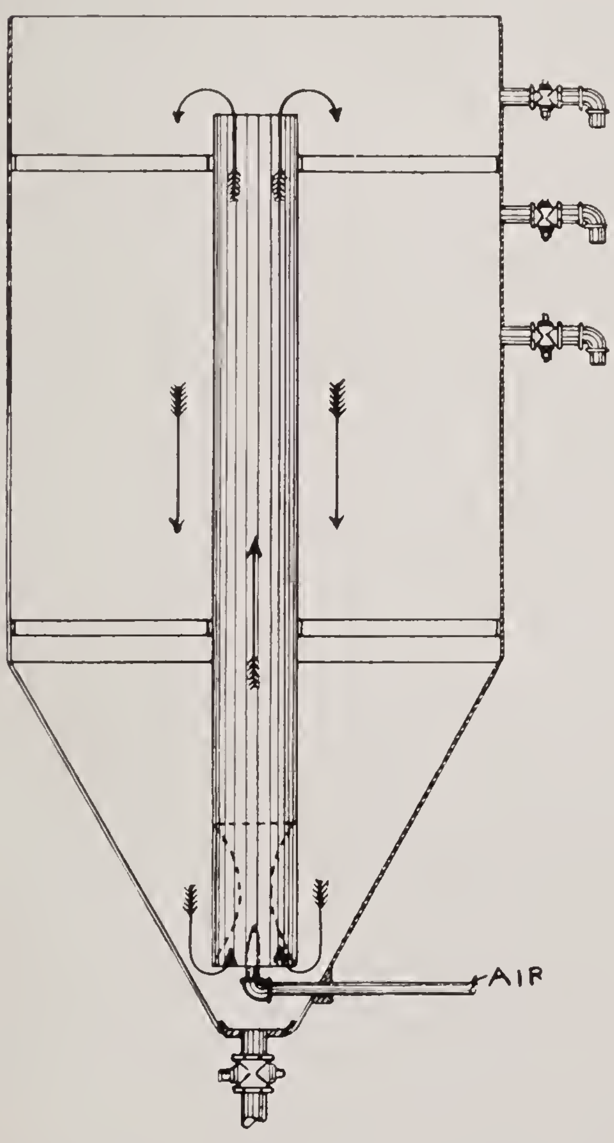
In downward percolation, it is usual to apply a sufficient quantity of solution to displace the previous solution, as soon as the latter has sunk below the surface of the pulp. The solution last added will then follow the previous one down through the ore without mixing with it to any appreciable extent, the level of the solution indicating the time at which the new solution appears in the discharge. In this way the time is known when, instead of sending the solution to the gold tank for precipitation, it should be run to a sump for reuse until the value is brought up to a sufficient amount for precipitation. This is continous leaching, in which percolation is carried out by the displacement of one solution by the one following. In some instances it has been found that better results can be obtained by intermittent treatment, in which the tank of pulp is allowed to drain completely between the different applications of solutions and wash water, this is probably due to the æration of the pulp by the air coming into contact with it.

The extent to which the washing should be carried can also be worked out when the plant is in operation. It is always better to add a large number of small charges than a small number of large ones. The first two or three washes very greatly reduce the value left in the pulp and succeeding ones remove comparatively little, as the last remaining values, although they may be in solution, are retained very tenaciously.

The salt, potassium cyanide, varies in purity, and different grades are designated by the percentage of pure salt contained. Thus 98 per cent. potassium cyanide contains 2 per cent. of impurities. Sodium, having a lower atomic weight than potassium, has a greater saturating power for other elements. This has led manufacturers to label sodium cyanide in terms of its equivalent in potassium cyanide, giving rise to such expressions as "130 per cent. cyanide." These points should not be lost sight of in purchasing cyanide for the fol-

lowing reasons: The impurities present in cyanides are not inert, but consist largely of sulphides and other detrimental compounds. All commercial potassium cyanide contains more or less sodium cyanide, and if a large amount of impurities are present, the sodium cyanide present will, if in sufficient quantity and expressed in terms of potassium cyanide, give a percentage figure indicating a high degree of purity. The strength of solutions used in cyaniding is expressed in pounds per ton of water, a "five-pound solution" meaning one containing five pounds of the solid salt in one ton of water. For the best results, the amount of cyanide used should be as low as possible and still leave a slight excess to facilitate precipitation. The actual amount used varies so greatly that definite figures cannot be given, but it is generally very small.

If the pulp produced contains an excess amount of very fine material it cannot be treated by percolation, and the slimes must be separated and handled by special methods. The separation of sands from slimes is best effected by means of mechanical classifiers, which are in every way superior to hydraulic cones, spitzkästen and similar devices.



The slimes separated by the classifiers carry a large amount of water, or solution if crushed in cyanide, and it is necessary that the excess be removed in order that the moisture carried by the slimes will not greatly dilute the solution when applied. This thickening is accomplished in thickening tanks, which may be simple cone bottom tanks but preferably special thickeners, having a large settling area with rakes in the bottom to move the thickened product to a conveniently located cone from whence they may be drawn continuously.

The treatment of slime is by agitation in a solution of suitable strength, for a time dependent upon the rate of dissolution. The method of agitation now almost exclusively used is by circulation, using centrifugal pumps or an air lift within a tall tank. The annexed illustration is reproduced from our catalogue, number 10-A,

published in 1905, and represents what is now in general use with a few minor changes, under the name of the "Pachuca" tank.

Recent important patented improvements in agitation tanks are provisions for starting after the slime may have settled hard from the tank being temporarily out of operation; for continuously withdrawing pulp from the tank, the part so withdrawn being of the same physical condition as the contents of the tank, thus preventing the accumulation of sands in the bottom and, where centrifugal pumps are used for agitation, for preventing all but the very finest solids from passing through the pump.

The following schemes of slime treatment are applicable to the slime end of a mill treating sands by leaching, but are designed particularly as complete methods for handling the entire mill output ground to what is practically a slime product by tube mills. These methods, on which patents have been applied for, are presented as an approach to the ideal and a practical realization of the ultimate simple, continuous, automatic process toward which the best practice has been tending during the last few years. The principle of counter-currents is applied in an extremely simple manner, with the use of thoroughly efficient equipment, such as is now in use. The method first described was published by Mr. John E. Rothwell in Metallurgical and Chemical Engineering for September, 1911.

Reference to the graphic flow sheet which follows, will show that instead of the customary arrangement of the agitators in continuous series, the agitators alternate with thickeners, each agitator receiving the thickened pulp from the thickener ahead of it and the decanted solution from the thickener following it. It will thus be observed that the solvent is taking up value from the ore of lowest value and passing it up to the tank containing a higher value, while the ore is losing value as it passes down through the successive tanks toward the discharge.

This method is a wide departure from the practice used heretofore, and has many advantages, the more important of which are as follows:

The dissolved values are recovered from the system at the point fartherest removed from the discharge of the tailings; thus it is impossible for a charge of pulp containing high value in solution to be thrown away by an imperfect wash or carelessness or neglect on

the part of the attendant operating a filter, as may happen with the older method.

The solution carrying the pulp which passes to the filters is very low in value, promoting efficient washing.

The amount of solution carried in the circuit is less than in other methods, while at the same time any unit of ore is in contact with a larger volume of solution than at present.

By proper regulation, a minimum of solution of constant maximum value is sent to the precipitation department, so that there is no occasion to carry two or more circuits for precipitation purposes.

There will be no accumulation of solutions from which the values have to be precipitated and the solution thrown away.

The power required for operating will be less and the equipment less for given tonnage capacity, thus the first cost for installation will be less per day-ton treated.

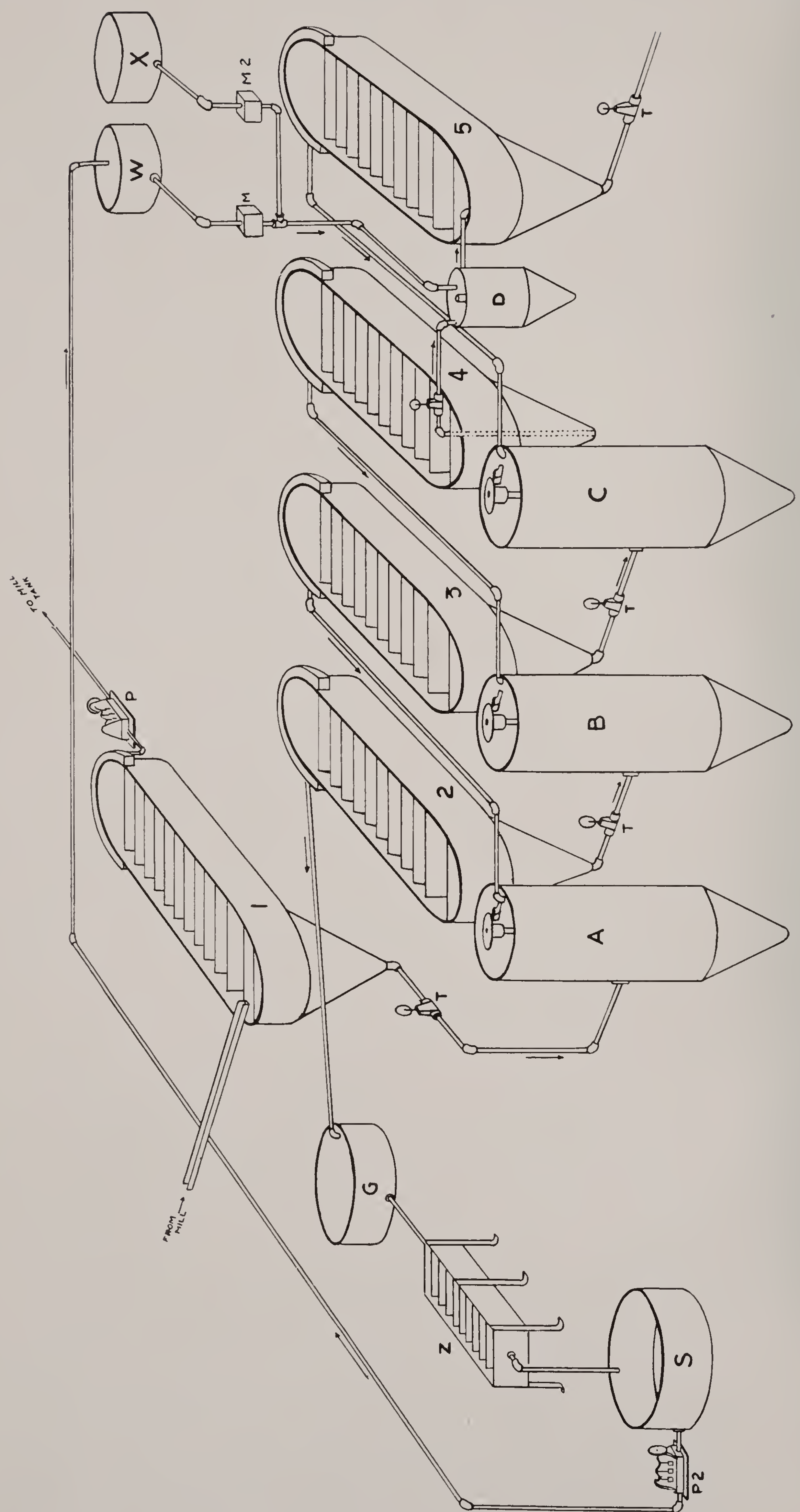
The two circuits maintained through the agitators and thickeners may readily be followed by reference to the sketch.

1 is the mill pulp thickener which receives all of the overflow from the slime classifiers, the clear overflow going back to the mill solution tank except the small amount sent to G for percipitation if there is a tendency on the part of this mill solution to build up in value. This solution, instead of being sent to G, might, in some cases, be sent to 4 or 3, whichever should happen to contain a nearly equal value per ton of solution. The underflow will be transferred in definite quantity and specific gravity by the automatic transfer T to the first agitator A.

A, the first agitation tank, receives the thickened pulp from 1 and the counter current solution from the overflow of 3. The contents of this agitator are delivered to thickener 2 by the adjustable sampling vane placed above the pulp level and which assures the continuous flow of a certain quantity without favoring coarse or fine, solid or liquid.

2, the first dewatering thickener, receives the flow from the sampling vane of A, the clear overflow going to G and the thick underflow by automatic transfer to B.

B, the second agitation tank, receives the thick pulp from 2 and the counter current solution from the overflow of 4, and dis-



THE COUNTER CURRENT METHOD OF CONTINUOUS AGITATION.

charges its contents continuously at the same rate of flow as received, through the sampling vane to 3.

3, the second dewatering thickener receives the flow from the sampling vane of B, the clear overflow goes to A, while the thickened underflow goes through the automatic transfer in definite quantity and specific gravity to C.

C, the third agitation tank, receives the thick pulp from 3 and the counter current solution from the overflow of 5. It discharges its contents in equal quantity as received, through its sampling vane to 4.

4, the third dewatering thickener, receives the continuous flow through the sampling vane from C. The clear overflow goes to B, while the thickened underflow goes through the automatic transfer in definite quantity and specific gravity to D.

D, mixing tank, receiving the thickened pulp in definite quantity and specific gravity from 4, together with a continuous flow of barren solution from W equal (plus the proper quantity of water from X to make up for the moisture passing into the circuit from 1) to the counter current flow. The contents of this agitator overflow continuously into 5.

5, the fourth dewatering thickener, receives the pulp overflow continuously from D, the clear overflow going to C. The thickened underflow goes through the automatic transfer to waste, if sufficiently low in dissolved value and cyanide. If this pulp, however, contains too much value to waste, intermediate thickening tanks are placed between 4 and 5 and the overflow from 5 mixes with the thickened pulp going to the thickener immediately preceding it. If, however, it is desirable to filter and wash the thick slime, a revolving drum or pan continuous filter will follow 4, the thickened pulp being delivered to the filter by the automatic transfer in the same manner as to D in the sketch.

G, gold solution tank, receives the overflow from 2 and delivers to Z as required.

Z, zinc boxes, receive solution from G and deliver barren solution to S.

S, barren solution tank, receives solution from Z from which it is raised by the pump P2.

P, P2, pumps used to transfer solutions from 1 to mill solution storage tank and from S to mill storage and to W.

W, solution tank for barren solution used in counter current. Receives solution from S, through P2 and delivers to M.

M, M2, measuring tanks or flow meters, receiving barren solution from W and wash water from X, delivering in definite registered quantity to D.

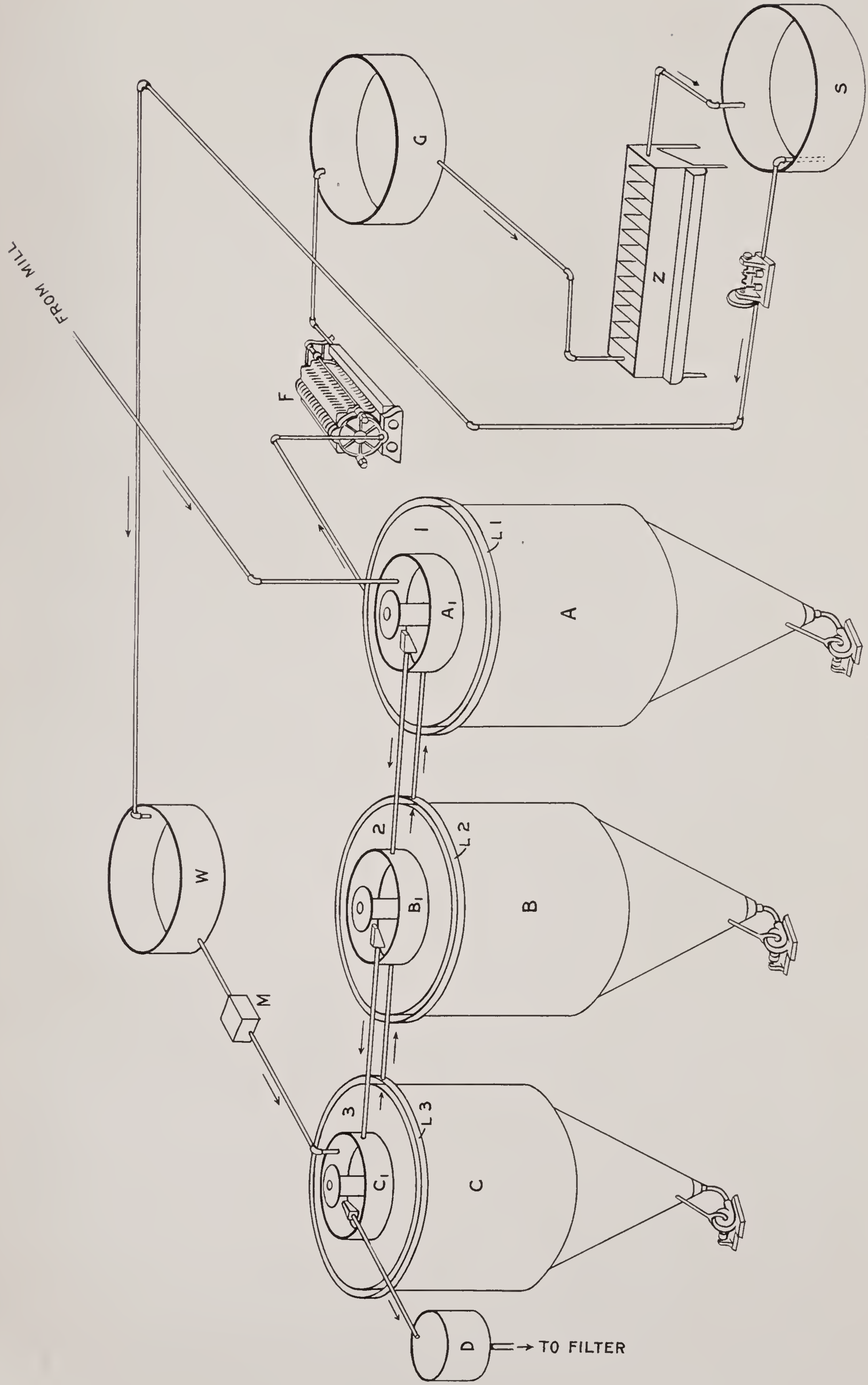
X, water tank.

The Rothwell-Lowden method, another and simpler means of application of the counter current method of continuous agitation, is illustrated in the following outline perspective drawing. In this, the thickening tanks are dispensed with and a quiet space provided within each agitation tank. This annular space is furnished with inclined baffles, similar to those employed in the Rothwell thickener, which greatly increase the settling area, and the solution drawn off is substantially clear and practically no solids are carried back by it. To remove any turbidity of the solution previous to precipitation it is passed through a clarifying filter previous to going to the gold tank. The method of operation is as follows:

A, B, C, are Akins-Rothwell agitation tanks arranged for continuous series agitation and each fitted with an inner cylinder A_1, B_1, C_1, and an overflow launder L_1, L_2, L_3. In the annular area between the cylinder and the curb of the tank are placed inclined baffle plates, the tops of which are submerged.

The slime pulp to be treated flows from the grinding mill to the space within the inner cylinder A_1, in which it is kept agitated by pneumatic or mechanical means, or both. A definite proportional part of the pulp is cut out continuously by the cutting vane and passed on to the space in the inner cylinder B_1, in which the same operation takes place, the pulp passing to tank C and so on to the subsequent tanks of the series.

While this operation is going on, barren cyanide solution is passed from tank, W, through the meter, M, into the space in the inner cylinder of tank C, or the last tank of the series when more than three tanks are used, and this solution mixes thoroughly with the pulp being agitated, thus diluting the values carried in solution. Separation of the solids from the liquid is made by gravity in the quiet annular space 3, the solids remaining in the tank while the solution overflows the weir into the launderer L_3 in quantity equal to the inflow from W. From the launder L_3 the solution flows to the



THE COUNTER CURRENT METHOD OF CONTINUOUS AGITATION.

space in the inner cylinder B_1 of tank B, in which the action and operation are the same as in C, the overflow going from the space 2 to the inner cylinder A_1 of tank A.

The counter current solution, passed from W into C, diluting the values in solution in that tank, flows back through the series of tanks, coming progressively in contact with richer pulp and gathering values in its course, finally overflowing from L_1 carrying a maximum value. This is the solution which is precipitated, for which purpose it is passed through the clarifying filter, F, to remove any turbidity and thence to the gold tank, G, from which it flows to the zinc boxes, Z, in which the gold and silver are precipitated. The barren solution from the zinc boxes flows to the tank, S, from which it is pumped back to the tank, W, is built up in cyanide strength and re-enters the circuit.

In the meantime the pulp has been passing through the series of tanks in a direction opposite to the flow of the solution, whereby it progressively comes in contact with solution lower in dissolved values and higher in free cyanide as the pulp becomes reduced in value, finally passing from C into the collecting tank, D, from which it goes to the slime filter. This filter separates the pulp and washes from it the soluble values it carries, delivering the solids to waste. The filtrate, being low in value, passes back to the grinding mill circuit, where it is built up in cyanide strength and resumes its flow through the system.

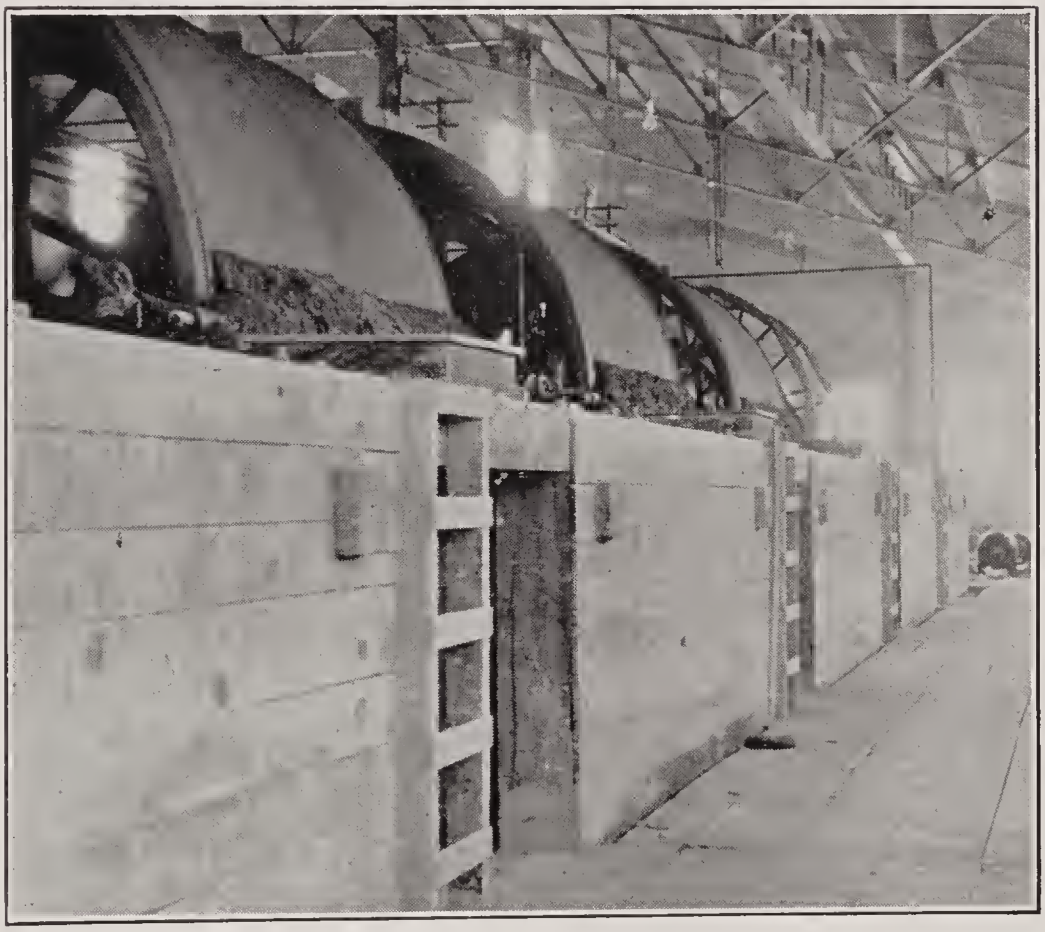
This method of operation secures all the metallurgical advantages of the counter current principle as well as all of the operating advantages mentioned in the counter current method first described, together with further simplification and less equipment.

III. Slime Filtration.

The problem of separating the slime from the valuable solution in which it is carried has been attacked from many directions and with such success that sliming is now deprived of its terrors and fine grinding with handling of the entire ore by slime treatment methods is the basis of most of the more recent and economical work.

Among the numerous slime filters at present in use, the older are subject to various disadvantages, particularly in being inter-

mittent in action, expensive in installation and requiring considerable attention. Filters of the revolving drum type are continuous, automatic in operation, compact and low in cost and expense of maintenance. The most improved of the revolving drum filters provides for washing under a higher vacuum than is used for loading if desired, also for washing with both weak solution and water, with separate delivery of each, thus accomplishing all that is desirable in respect of final washing of the slime and ability to properly dispose of the solution and water washes in the mill circuit.



PARTIAL VIEW OF AN INSTALLATION OF SIX PORTLAND FILTERS.

Slime can be separated from the valuable solution and washed by a system of repeated dilution and thickening but not without the addition of considerable volumes of water to the mill circuit. In washing on the filter, however, the final wash water can be regulated to an amount substantially equal to the moisture remaining in the cake at discharge so that there will be practically no addition to the amount of liquid carried in the circuit and no necessity of running large quantities of solution to waste.

The work of revolving drum filters containing these features is fully equal to any others, and where the soluble values in the pulp

have been low, as they ought to be at this point in a well-regulated plant, a mere displacement wash has given extremely low tails.

IV. Precipitation of the Gold and Silver.

Whether obtained from sands or slimes, the precipitation of the values from the solution is generally best made by zinc, either in the form of fine shavings or dust (zinc fume). It was very largely due to the efficiency of the MacArthur-Forrest zinc precipitation method that the cyanide process found such ready acceptance, previous attempts having been mostly in the direction of precipitating the values from the pulp without first separating it from the clear solution. Could precipitation be effected from the mixture of ore and solution after the dissolution of the gold and silver the cyanide process would be very materially simplified and shortened, but experience has shown the necessity of using clear solution, as the presence of solid matter in suspension exerts a very detrimental effect.

Precipitation by zinc shavings is very simple, and consists merely in passing the solution slowly through loosely packed zinc shavings contained in boxes of such design as to insure intimate contact of the solution and zinc. The results are best with fresh zinc, and it is customary to cut the shavings from sheet zinc at the mill, in a simple automatic lathe designed especially for the purpose.

There is considerable difference of opinion among operators with respect to the minimum strength and value of solutions which it is economical to precipitate, but under ordinary conditions it is best to have a small excess of free cyanide present. Opinions also vary as to the extent to which the values should be removed and in this, as in other steps in the process, it is possible to carry the precipitation to a point beyond which it proves economical. The remaining values of a few cents per ton of solution are not lost, nor is the excess cyanide, but the solution is run to a sump tank and used again after being brought up to strength.

In precipitating very weak solutions, the gold and silver frequently deposit upon the zinc in a hard film, interfering with the efficiency of the zinc as a precipitant. This can be avoided by the use of a zinc-lead couple, formed by dipping fresh zinc shavings in a solution of lead acetate immediately before placing them in the zinc boxes, so as to coat them with metallic lead to the extent of about

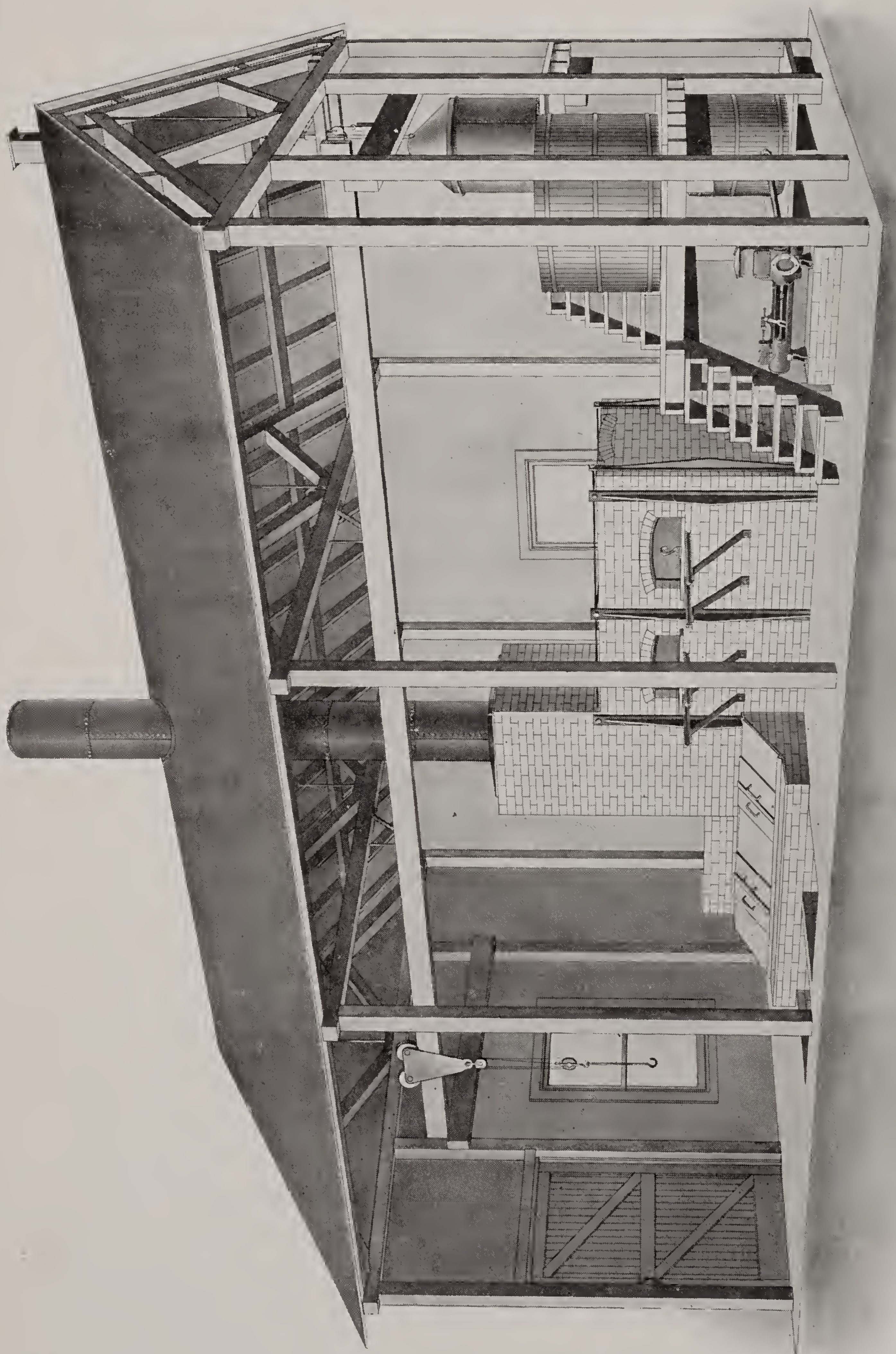
1 per cent. of the weight of the zinc, which causes the precipitate to form as a loose deposit.

The other method of precipitation by zinc is with zinc fume, which consists of a powder of zinc containing more or less impurities obtained as a by-product in zinc smelting. The impurity present in largest quantity is zinc oxide, which is usually removed by treating the fume with dilute ammonia. In this process the zinc dust is mixed with the solution in proportion sufficient to precipitate the values and, after agitation in suitable apparatus, the whole is passed through a filter press, the solution going to the sump tank and the precipitate being obtained in the form of cakes. In a largely used patented process, the zinc dust is treated mechanically in a miniature tube mill, fed to the solution in definite quantity while in motion and forced into a filter press without exposure to the air.

V. Cleaning Up, Refining and Melting.

The precipitate obtained by filter pressing as above described is ready for the process of refining. The clean up from the zinc boxes in precipitation by zinc shavings is carried out somewhat as follows: A strong cyanide solution is run into the zinc boxes to loosen the precipitate, after which clean water is run in, sometimes with a little acid and alum to promote settlement. The shavings are shaken in the water to loosen adhering precipitate and after settling, the water is siphoned off and the precipitate removed in buckets or washed out if the zinc boxes are suitably arranged. In many of the larger plants the precipitate from the zinc boxes is filter pressed, which makes a great saving in time. The clean up occurs at intervals of one to four weeks, usually every two weeks.

Following the collection of the precipitate in a moist condition the reduction to bullion may be accomplished in different ways, as: Drying and direct smelting; Drying, roasting and smelting; Acid treatment, drying and smelting; Smelting direct with litharge and cupelling; and feeding the dried precipitate into a bath of lead in a reverberatory smelting furnace with subsequent cupellation of the lead. Each method has advantages and disadvantages and a consideration of all the conditions will indicate which will most likely prove best for any particular plant. These operations vary in details as conducted in different plants, and for this reason a state-



ment of the exact procedure in one case would not represent the operations in another where conditions were different; however, the illustration of a complete refining room shown on the opposite page will assist in an explanation of the final steps in the cyanide process resulting in the production of bullion.

The gold precipitate and zinc shavings from the zinc boxes are screened through a 20-mesh screen and the product placed in the vacuum filter tank, which is the lowermost of the three tanks shown. The pump exhausts the air from beneath the filter bottom and dries the precipitate, which is then placed in pans and dried and calcined in the muffle furnace, after which it is charged into crucibles together with the necessary fluxes and melted in the crucible furnace, the doors of which will be seen just above the floor level. The ash pits immediately in front of the crucible furnace are provided with covers of steel plate, not shown, and an overhead traveler with hoist serves for handling the crucibles and pans. After fusion the melt is poured into conical moulds in which the bullion settles to the bottom and the slag collects at the top, the slag being detached after cooling.

In continued operation a large amount of "shorts," *i. e.,* short zinc that will pass a two or three-mesh sieve but not a 20-mesh, accumulates after a time and as these cannot be utilized in the zinc boxes they are screened out and given the following treatment: They are first placed in the acid treatment tank, the uppermost one in the illustration, and a solution of one part sulphuric acid to about three parts water is added for the purpose of dissolving the zinc, which would otherwise cause the bullion to be of too low grade. The reaction is at first quite rapid, but toward the end agitation, or heating by steam also, if convenient, is required. This tank is lead lined and provided with a hood to conduct the noxious fumes developed to the outer air; the hood is provided with a length of pipe telescoping within the stationary portion and is counterweighted to facilitate access to the interior of the tank.

After solution of the zinc, the charge is let into the washing and decanting tank shown just above the pump, hot water added, and the precipitate washed by decantation two or three times to eliminate the zinc sulphate formed in the acid treatment. The residue, now freed from the great excess of zinc, is washed into the filter tank and the treatment continued in the manner first described.

Preliminary Tests.

A few tests will serve to determine whether or not an ore is amenable to treatment by the cyanide process, and in most cases the line of further experimentation will be indicated, at least in a general way. For the working out of a system of treatment which will give the best possible results in regular operation a much more extensive series of tests is demanded. These latter tests should be on larger quantities of ore than the preliminary ones and the conditions obtaining in actual practice should be simulated as closely as possible.

The methods of conducting tests of this nature cannot be entered into with sufficient detail here. They will be found in the more important treatises on the cyanide process, and in any event should be entrusted only to those having knowledge and experience in this special field. The physical properties of an ore and the composition as indicated by chemical analysis can at best but indicate the direction of the investigation; the final tests are experimental in their nature and, if intelligently prosecuted and methodically recorded, lead by a process of elimination to that system which, all things considered, will prove the best one to adopt.

That the best method of treatment for any ore can be determined in this way is no longer disputed. While variations will be found between the results obtained and those secured in actual working on a large scale, they are too small to affect the general result, and, as they concern different steps in the process, these experimental errors tend to balance each other. In short, it may confidently be asserted that cyanide tests are at least as reliable as tests of the metallurgical treatment of ores by any other wet method.

If the general lines of treatment are well chosen and additional tests upon the current product have proved them advisable, slight changes in the treatment can be made and the highest economical recovery attained and maintained. Not so if the method and equipment are not those best suited to the ore.

Those desiring to have ores tested are invited to communicate with us for information as to quantity of ore required, cost of the investigation and other particulars.

Mill Plans.

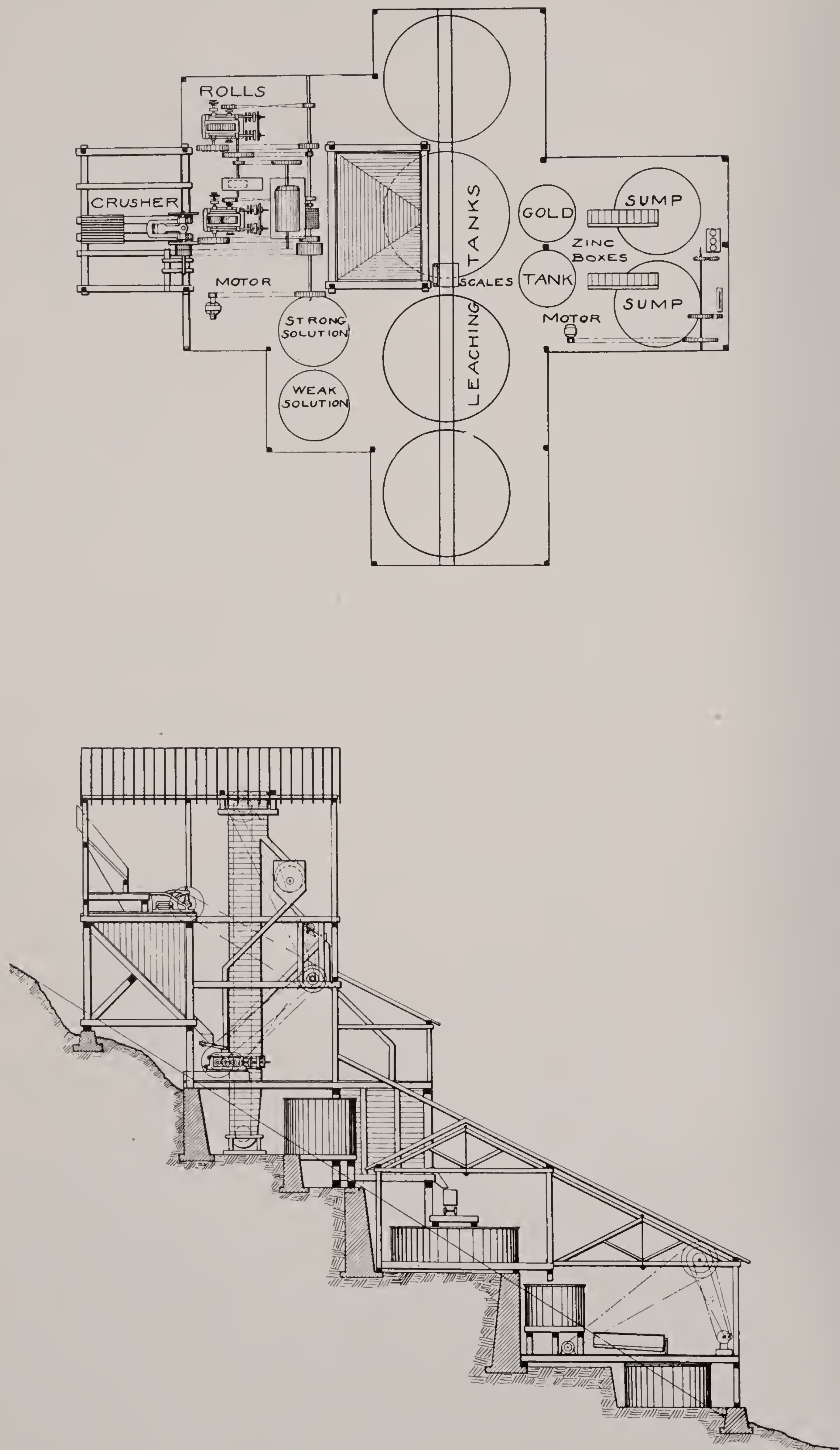
In the present edition of our cyanide catalogue we have decided to show drawings of but two mills and these of the simplest kind. The reason for this is that in large plants it is usually economical to add a number of refinements not essential in small installations, and as these details differ according to circumstances, it would be impossible to present plans of large plants which would be of general application.

A description of a metallurgical process such as it is our custom to publish as an introduction to our catalogues, can at best but give an outline of the state of the art at the time it was written and where rapid advancement is being made, as is the case with the cyanide process, such description must soon become obsolete. This is forcibly illustrated by the last edition of this catalogue, the introduction to which the short four years since it appeared have served to render totally unsuitable to reprint as a description of the cyanide process as it stands today. The most noteworthy change in practice has come from the solution of the slime problem, resulting in the possibility of the sufficiently fine grinding of the whole ore to handle it by slime treatment methods. This has led to simplification of equipment, uniformity and ease of control and to a decrease in the cost of operation.

Mill plans are even more apt to become unsuitable than descriptive matter, especially plans of the larger mills, and as the present aim is to acquaint those without knowledge of the process with the general methods and the reasons therefor, any specialization is superfluous and can be submitted where the occasion for it arises.

We treat each problem according to the special conditions and it has been our experience that, except with the simplest plants, there are no two propositions which can be met in the same way.

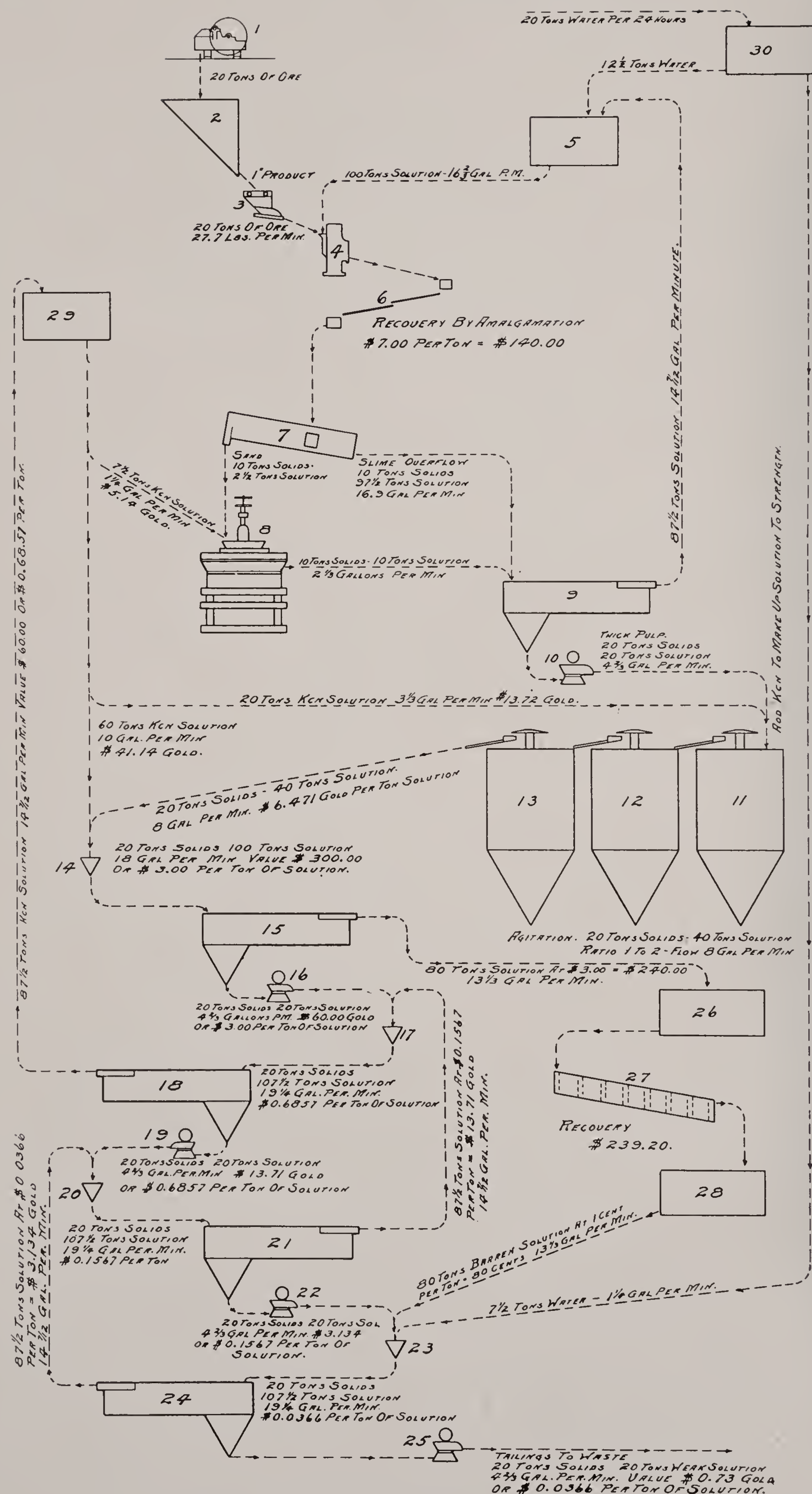
A large and varied experience in the design and building of cyanide plants keeps our engineering department at all times supplied with drawings made for special cases, which, while not applicable to other conditions, are of great value in the preliminary discussion of plants requiring treatment along similar lines. These we are always ready to submit on occasion and we solicit inquiries from those projecting cyanide plants accompanied by all available data as to conditions and requirements.



A SMALL DRY CRUSHING PLANT.

A Dry Crushing Cyanide Plant.

We have illustrated herewith a general arrangement of one of the simplest of the dry crushing process plants. In this plant the ore is received from the mine in cars and delivered to the mill first over the grizzley above the ore bin, the product of the grizzley passing direct to the ore bin, and the oversize from the grizzley going through the crusher and from the crusher into the same bin. From the ore bin it is fed by a plunger feeder to a set of rolls adjusted for coarse crushing, the product of the rolls going to the elevator and being elevated to a revolving screen, usually of 3/16 or ¼-inch aperature, wire cloth or perforated metal. The oversize from the revolving screen is returned to the coarse crushing rolls, while the portion which has passed through this screen goes to an impact screen having screen cloth of suitable mesh, this depending on the size to which it is necessary to crush the ore. The product passing this impact screen passes direct to the storage bin, the oversize going to a second set of rolls set for fine crushing, the product of which is returned to the same elevator. The finished product in the storage bin is loaded into a car that runs on a track over the leaching tanks and the tanks are loaded with a given quantity of this sand product until they are within about three or four inches of the top. Cyanide solution of some definite strength is usually admitted at the bottom of the tank through a filter and allowed to rise to the surface as the sand is charged to the tank, then the operation is reversed and cyanide solution admitted to the top of the tank and leached through and into the gold tanks; this operation being continued as long as values are economically extracted from the sand. The gold tanks provide a storage for the valuable solution, and from them it is drawn through the zinc boxes in which the gold is recovered, the barren solution then going to a sump tank, from which it is pumped to the solution storage tanks, there regenerated with cyanide and used again in the sand leaching tanks. The zinc boxes are cleaned up at intervals and the gold contained therein separated from the coarser zinc and sent to the refining plant, where it is fluxed and melted into bars.



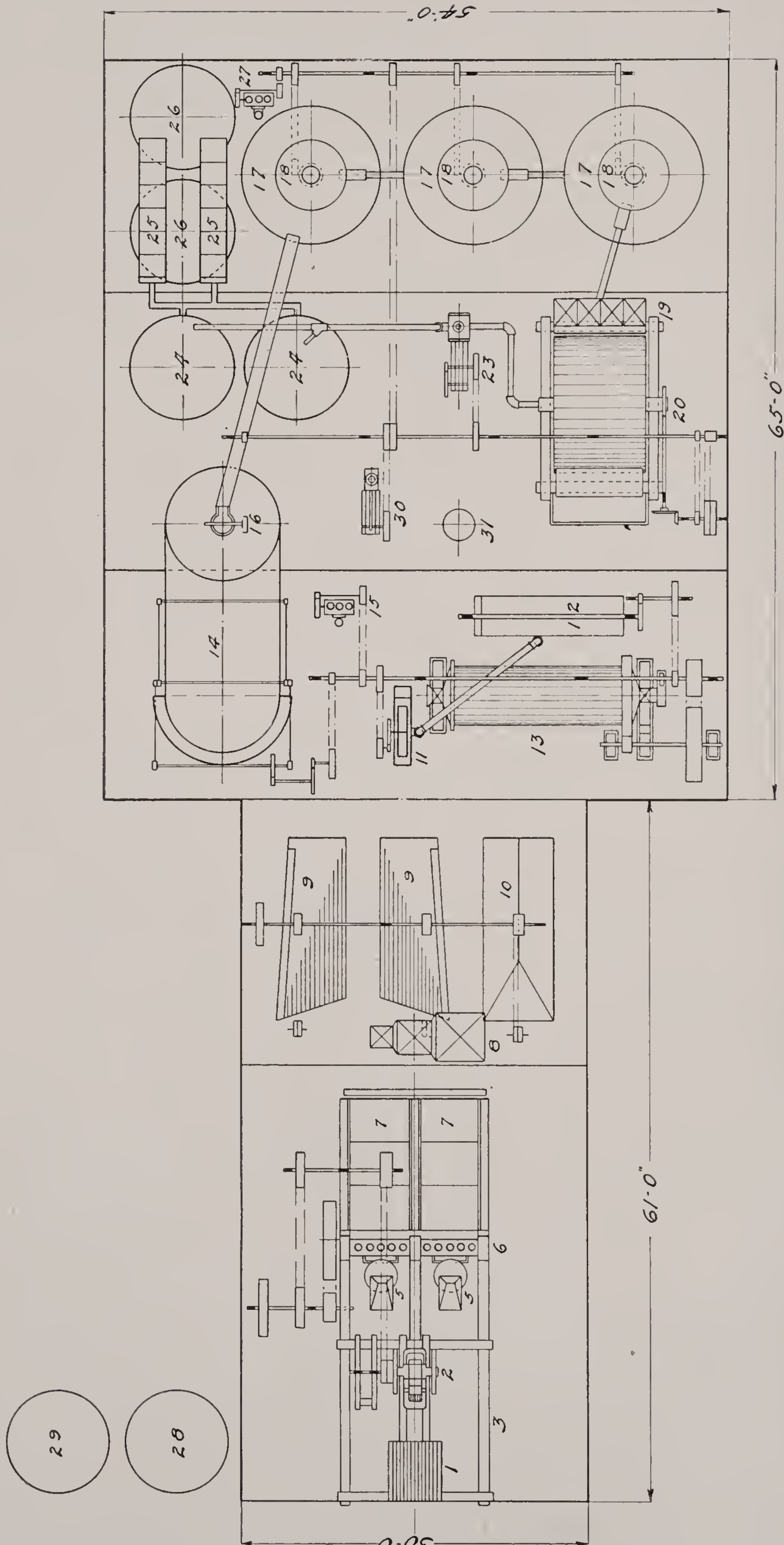
WASHING BY CONTINUOUS DILUTION.

Washing by Continuous Dilution.

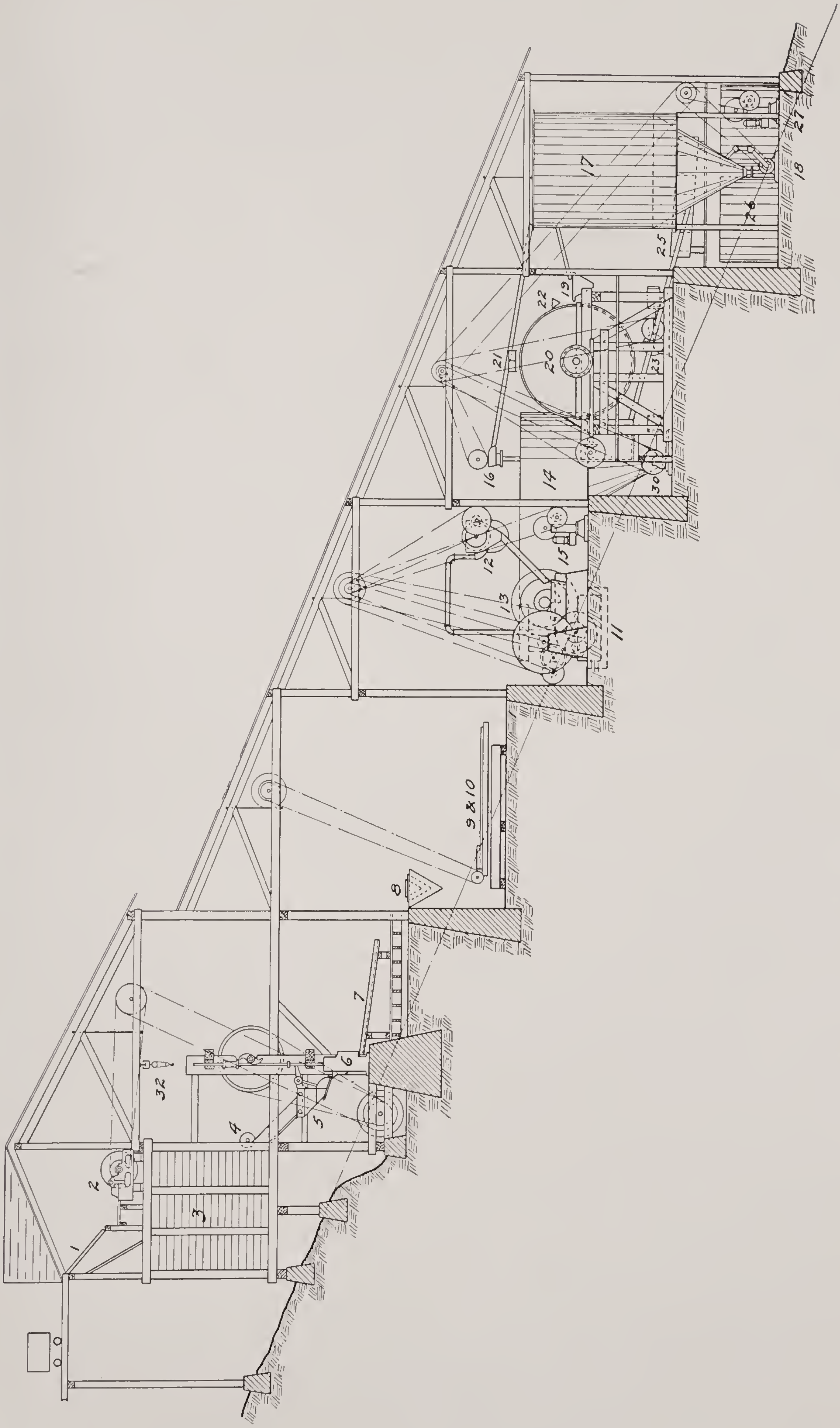
The annexed flow sheet illustrates a continuous method of amalgamation and cyanidation, using the patented system of continuous agitation in connection with washing by progressive dilution.

For the purpose of illustration, certain arbitrary assumptions have been necessary. These are: An ore carrying $20.00 per ton in gold and a daily capacity of twenty tons; the total recovery being taken at about 95 per cent., $7.00 by amalgamation, $12.00 by cyanide, with a loss in the tailings of $1.00 insoluble, and $0.0366 soluble value. The flow sheet has been made self-explanatory as far as possible, and will be readily understood with the help of the following key:

1, A 7 x 10 Blake Crusher.
2, The Ore Bin.
3, The Battery Feeder.
4, A Five-Stamp Mill.
5, The Mill Solution Tank.
6, Amalgamation Plates.
7, Akins Sand and Slime Classifier.
8, A five-foot Continuous Grinding Pan.
9, The Mill Thickener.
10, Adjustable Stroke Diaphragm Pump.
11, 12, 13, Three 1055 Cu. Ft. Akins-Rothwell Agitation Tanks
14, A 30-inch Mixing Cone.
15, The First Dewatering Thickener.
16, Adjustable Stroke Diaphragm Pump.
17, A 30-inch Mixing Cone.
18, The Second Dewatering Thickener.
19, Adjustable Stroke Diaphragm Pump.
20, A 30-inch Mixing Cone.
21, The Third Dewatering Thickener.
22, Adjustable Stroke Diaphragm Pump.
23, A 30-inch Mixing Cone.
24, The Fourth Dewatering Thickener.
25, Adjustable Stroke Diaphragm Pump.
26, Gold Solution Tanks.
27, Zinc Boxes.
28, Sump Tank for Barren Solution.
29, Mill Solution Tank.
30, Water Tank.



ELEVATION OF AN AMALGAMATION, CONCENTRATION AND CYANIDE PLANT.



ELEVATION OF AN AMALGAMATION, CONCENTRATION AND CYANIDE PLANT.

Amalgamation, Concentration and Cyanide Plant.

The accompanying drawings show the general arrangement of a plant for the treatment of gold and silver ores, using amalgamation and concentration with fine grinding of the tailings, their cyanidation by agitation, and slime filtration for final recovery of the valuable solution. The plant illustrated will have a capacity of about fifty tons per day but any desired capacity can be provided for along similar lines. The power plant is not shown, as it is not material to the purpose in hand, and will be governed by local conditions.

The flow of the ore through this plant is explained below, using Dr. Richards' excellent method of description:

1, Ore Grizzley; oversize goes to 2, undersize to 3.

2, Blake Crusher set to reduce the ore to about 1½"; product goes to 3.

3, Mill ore storage bin.

4, Bin Gates.

5, Stamp Battery Feeders; receive crushed ore from 3 through 4, and deliver it automatically as required to 6.

6, Stamp Battery, in which the ore is reduced to pass a screen the size apertures of which is determined by the fineness of the ore necessary for the after treatment. The ore is crushed here in about five tons of solution to one ton of solids and passes through the screen to 7.

7, Silver Plated Copper Amalgamating Plates on which the coarse metallic gold and silver are caught in an amalgam, the tailings and solution passing to 8.

8, Three Compartment Spitzkästen; the underflow of the first and second compartments going to 9, underflow of the third or largest compartment, going to 10, and the overflow of the third compartment going to 14.

9, Concentrating Tables; receive the underflow of first two compartments of 8, concentrates going to storage bins, tailings with practically all of the solution going to 11.

10, Slime Concentrating Table; receives the underflow of the third compartment of 8, concentrates going to storage bin, tailings with practically all of the solution going to 11.

11, Sand Pump or Elevator; receives tailings and solution from 9, 10 and 13 and delivers to 12.

12, Akins Classifier; receives the flow from 11 and separates the sand from the slime, the sand going to 13 and the slime with most of the solution going to 14.

13, Tube Mill; receives the sand product of 12, together with sufficient solution to make the proper consistency for grinding. The ground product goes to 11.

14, Rothwell Continuous Pulp Thickening Tank; receives the overflow from 8 and 12. The clear overflow goes to 15 and the thick underflow goes by 16 to 17.

15, Triplex Solution Pump; receives the overflow from 14 and delivers it to 28.

16, Diaphragm Pump; removes the thick pulp from 14 continuously and delivers it to 17.

17, Three Akins-Rothwell Agitation Tanks; for the patented continuous series operation, receive the thick pulp in cyanide solution from 16 and carry it by continuous flow through the cutting vane on each tank, delivering it from the last tank of the series to 19.

18, Centrifugal Pumps attached to the tanks for agitation purposes.

19, Distributor for slime filter, receives the thick pulp continuously from the last agitation tank, 17, and delivers it at a constant rate to 20.

20, Portland Continuous Slime Filter; receives the thick pulp from 19, separates and washes the solids, the filtrate going through 23 to 24, the solids to waste.

21, Wash Water and Wash Solution Feed Pipes; receive wash solution from 29 and wash water from water storage, spray them on the slime cake on the filter medium through which they are drawn by 23.

22, Excess Wash Solution Box, to prevent wash solution from entering pulp loading tank.

23, Wet Vacuum Pump, draws filtrate from 20 and delivers it to 24.

24, Gold Solution Tanks; receive clear solution filtrate from 20 through 23 and deliver it to 25.

25, Zinc Shaving Precipitation Boxes, receive gold and silver-

bearing solution from 24, retain the gold and silver and pass the barren solution to 26.

26, Barren Solution Storage Tanks; deliver to 27.

27, Barren Solution Pump; draws solution from 26 and delivers it to 29.

28, Mill Solution Tank, receives from 14 through 15 and delivers into mill circuit.

29, Barren Solution Storage Tank; receives from 26 through 27 and delivers to mill circuit as required.

30-31. Compressor and Air Receiver; furnish compressed air for æration in the agitators and for the blow at point of discharge of the Portland filter.

The precipitate of gold and silver held in the zinc boxes is cleaned up at intervals and either refined on the ground and shipped as bullion or partially dried and shipped in sealed cans to some custom refinery or smelter.

Treatment of Sand and Slime by Agitation.

Some ores do not require reduction to an all slime product to obtain the maximum profitable extraction, but yield to cyanide by 30 to 40 hours agitation when crushed to 24 or 30 mesh. Formerly, the treatment of such a product would have involved the separation of the sands and slimes preliminary to cyanidation, with leaching of the sands in sand tanks and the dewatering and treatment of the slimes by agitation and filtration.

A method which we have devised, eliminates the sand tanks and provides for handling the entire product together in a practically continuous manner. The operation is as follows:

The product of the stamps, Chilean mills or the unclassified tailings from the concentrators are sent to an Akins classifier in which the sands are separated from the slimes, the former going direct to the first of a series of agitation tanks arranged for the patented system of continuous agitation, the latter, with the excess of solution passing to a Rothwell continuous thickener. The thickened pulp from the thickener is raised by a diaphragm pump into the first agitation tank and the clear overflow is returned to the mill circuit.

During agitation the pulp passes continuously from tank to tank and is discharged from the last tank of the series into an Akins classifier which separates the sand from the slime, the sand going to a two-stage Akins classifier where it is given a double wash and is discharged as waste. The water used for the final wash is passed to the classifier in which the first wash is given and from there to the final thickener, the slime overflow from the classifier immediately following the agitation tanks also going to this thickener. The clear overflow from this thickener goes to the gold tank and the thickened pulp to a Portland continuous filter where it is separated from the solution, washed and discharged to waste, the filtrate going to the gold tank. The solution from the gold tank goes to zinc boxes for precipitation of the values and the barren solution is returned to the mill circuit.

Where dry crushing is practised the dry pulp would be mixed with a definite quantity of solution and passed direct to the first agitation tank, the preliminary classification and thickening being dispensed with.

Double Concentration with Cyanidation.

With some ores it is necessary to crush and concentrate in water and then to dewater the tailings and continue the treatment by cyanide.

In a plant recently designed and equipped by us it was necessary to follow this line of treatment of an ore in which the mineral was very finely disseminated in a siliceous gangue and required double concentration, the second concentration after tube milling.

The final tailings from concentration are dewatered by first going to a Rothwell continuous thickener which delivers clear water at the overflow and a pulp containing about 60 per cent. moisture at the bottom of the cone. The thickened pulp goes to a Portland continuous slime filter with a tank giving about 60 per cent. submergence to the drum, and the loaded cake, dried to about 30 per cent. moisture is sprayed with a solution of lime, thus effecting neutralization of a minimum amount of the mill water, and then with cyanide solution just prior to discharge, to displace most of the water and prevent the accumulation of solution in the cyanide department.

The pulp from the dewatering filter is delivered to a mixer in which it is thoroughly incorporated with cyanide solution in the ratio required for agitation, passing thence into the first agitation tank. The agitation tanks are arranged for operation by the Rothwell-Lowden method of counter current continuous agitation described on page 18.

The pulp from the last agitation tank passes continuously to the Portland continuous revolving filter where it is separated from the solution, washed and discharged to waste, the pregnant solution for precipitation passing continuously from the first agitation tank through the zinc boxes and thence going in part to form the displacement solution on the dewatering filter but the bulk going back as the counter current through the agitators.

In this method the solution precipitated amounts to but two and one-half to three tons per ton of ore treated.

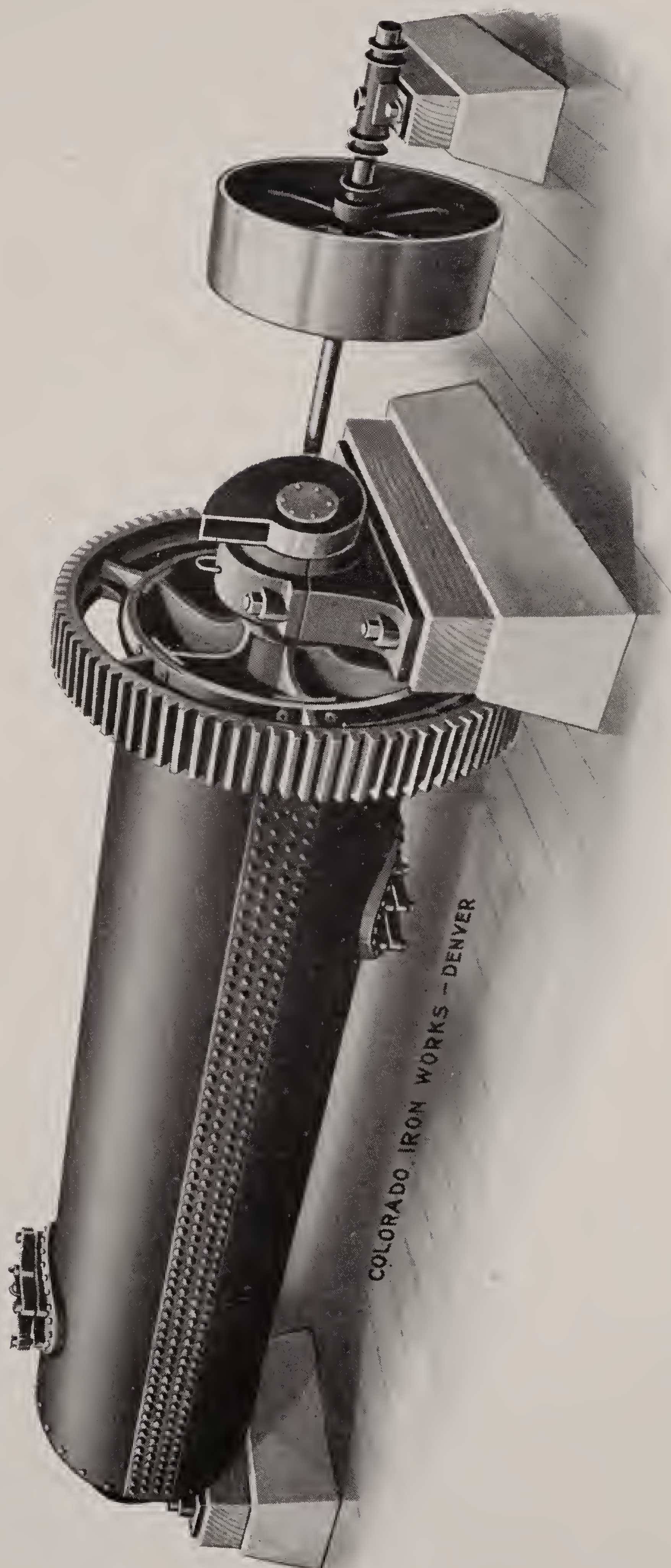
A Plant for Treating Accumulated Tailings.

A plant recently designed by us for treating a tailings pile having not over 15 per cent. minus 200 mesh, is briefly described as follows:

From the tailings pile the pulp is conveyed to a trommel covered with a $\frac{3}{4}$-inch mesh screen which removes chips, rock and other coarse debris that have accumulated in the deposit, the undersize passing to a storage bin. From the storage bin it is fed by a belt-driven plunger feeder to a mixer with addition of sufficient cyanide solution to make a thick pulp. In this the coarser lumps are broken up, the product flowing to a double log washer type of mixer in which three parts dilute cyanide solution is added for each part solids, the pulp then flowing to a slime pump which raises it to an Akins sand and slime classifier. This classifier separates the sand from the slime, the sand product going into a bath of water in a second Akins classifier where it is washed to save any values taken up by the solution which it carries as moisture and is discarded as waste.

The slime overflow from both classifiers goes to a Rothwell thickening tank, in which it is thickened to a pulp containing about one and three-fourths parts liquids to one part solids, the clear overflow going to a pump by which it is raised to the mill storage tank for reuse. The thickened pulp passes to the first of a series of four agitation tanks, connected for the patented system of continuous agitation, going successively through the four tanks and into a collecting tank of small capacity from which it is distributed to Portland continuous revolving drum filters which separate the solids and wash them to recover values carried as moisture, after which they are discharged to waste.

The filtrate from the Portland filters goes to a collecting tank, thence to a clarifying press and finally through zinc boxes for precipitation of the gold and silver. The barren solution from the zinc boxes goes back into the mill circuit, being brought up in strength for reuse, and the precipitate is melted into bullion.



45-INCH BY 15-FOOT TUBE MILL.

Tube Mills.

The past few years have served to strengthen the position of the tube mill as the best machine for the fine grinding of ores for cyanide treatment and they are to be recommended for this work in preference to all others except where small capacity and difficulty of transportation favor the use of grinding pans.

In the design and construction of our tube mills we have aimed to make them most substantial in every way, so that purchasers may be assured that none better can be obtained in all those details which make for efficiency and complete satisfaction in use.

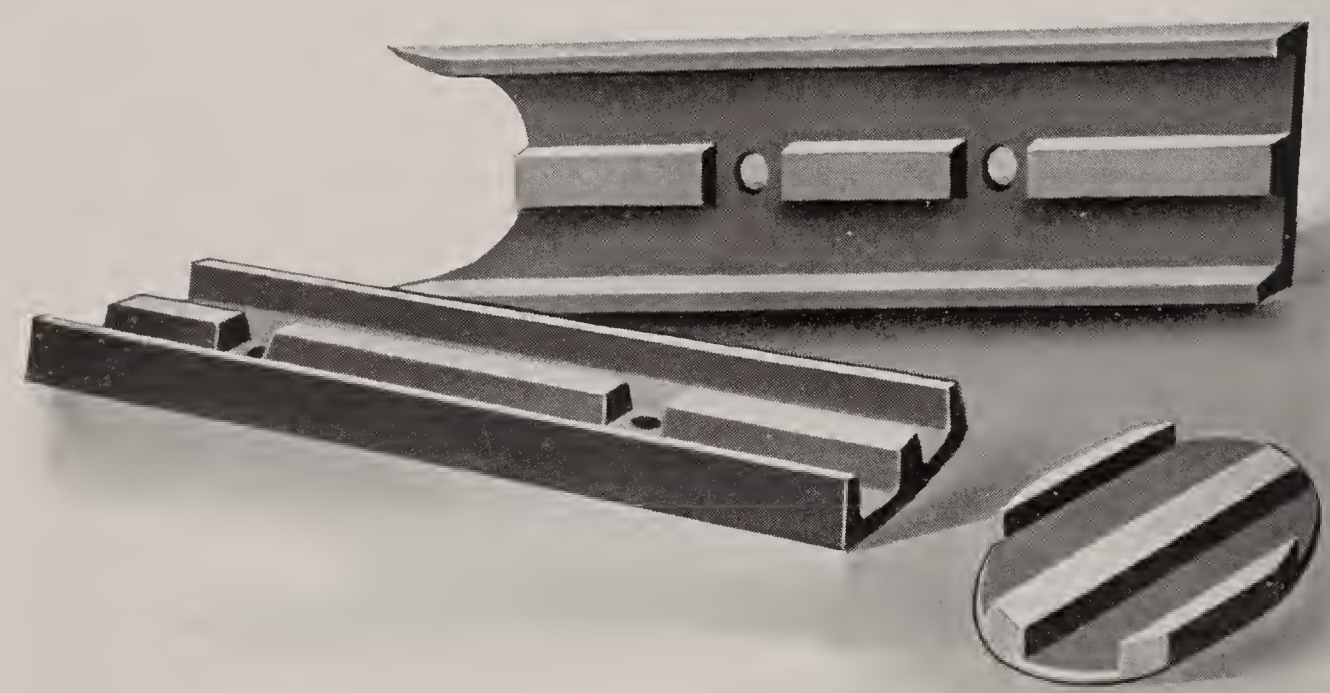
The heads are of cast iron heavily ribbed and the shells of heavy mill steel plates with outside butt straps so placed as to preserve the balance and insure smooth running. All rivets have countersunk heads on the inside, leaving the interior of the mill smooth. The scoop feed has proved a perfect means for supplying pulp to the mill and this part is made reversible, so that the mill may revolve in either direction. The discharge is through a large opening through the trunnion, provided with either a removable screen or a reverse spiral to prevent the egress of pebbles. The scoop feed is sufficiently large to admit the charging of pebbles through it while the mill is in operation.

Both main bearings are of the ball and socket type and very massive, and special consideration has been given to the manner of attachment of the gear, to enable its easy renewal when necessary. We provide two manholes, on opposite sides of the periphery, one near each end, that access may be had to all parts of the interior without removing the pebbles. The usual method of driving is by spur gears and friction clutch or tight and loose pulleys, but we also furnish a bevel gear-drive when desired. Prices are quoted for the mill complete without lining, which is extra. We recommend and usually supply El Oro lining, but if preferred, will furnish silex blocks, manganese or ordinary steel. We build tube mills in all sizes ordinarily used.

Tube mills are also built to run on tires, and claims are made by those who advocate this method, which are apt to be misleading. A cylinder mounted in this way may, and probably will, run easily when new, but the wear on the tires and rollers is extreme and the power required to drive the mill will, after a short period of use, greatly exceed that of one mounted on trunnions. The renewal of tires and rollers is a difficult operation, involving much labor and expense, and there are many bearings to look after, all in a bad location. The trunnion mill has but two bearings and, if these are proportioned to the load, they give no trouble and will maintain the gears in mesh and resist the driving thrust in the best manner possible.

El Oro Tube Mill Lining.

The most serious problems confronting tube mill operators concern the lining. A lining of silex blocks embedded in Portland cement gives a tube mill more capacity than a lining of plain hard iron or steel plates, as on the latter the charge of pebbles has a tendency to slide down in a mass instead of rolling over each other as they should. A silex lining, however, if not placed with special skill, is apt to cause trouble by portions falling out, and the time required to reline a mill with silex blocks, including the time necessary for the setting of the cement, usually puts the mill out of commission for five days.



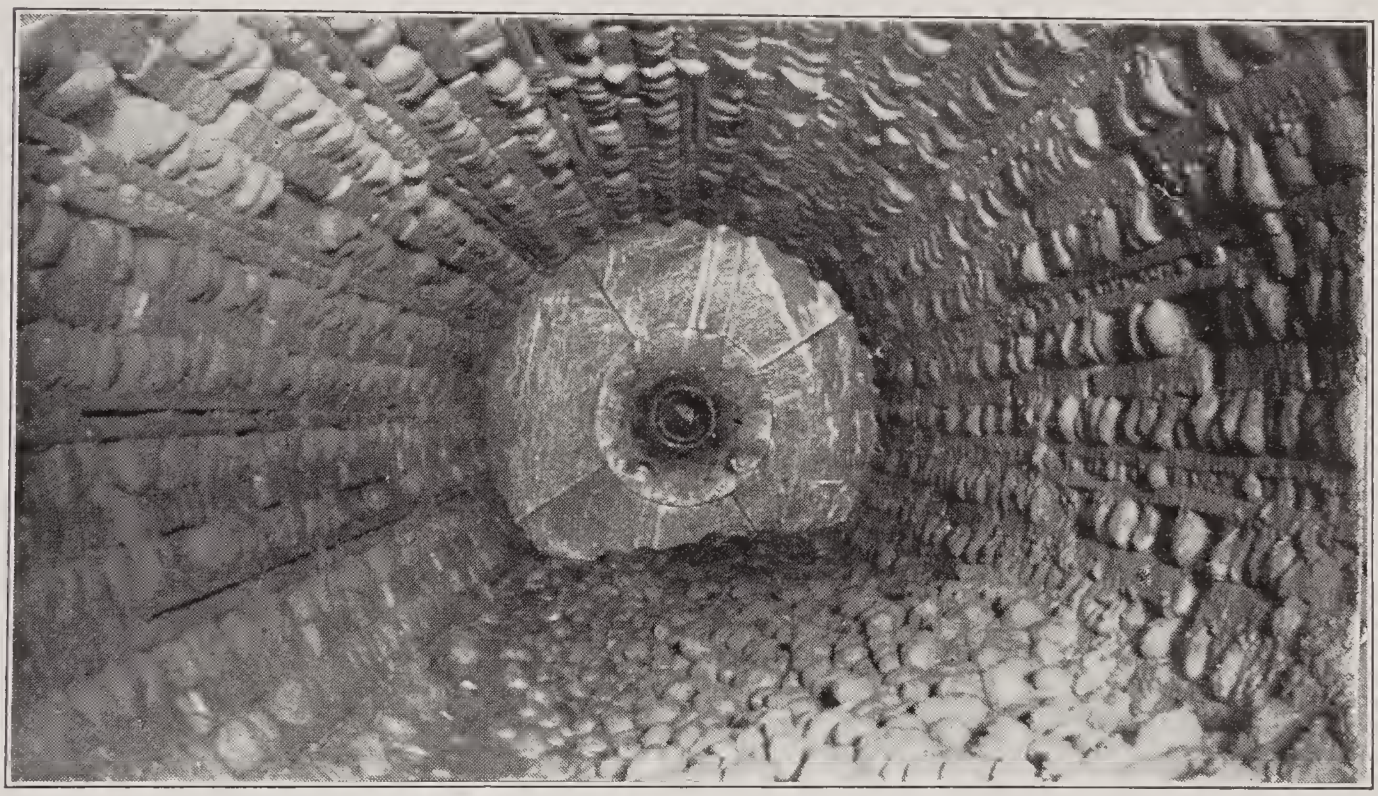
El Oro tube mill lining was developed at the plants of El Oro Mining & Railway Company, and the Compania Minera Las Dos Estrellas, at El Oro, Mexico, and consists of plates, usually of hard iron, having ribs of such form as will cause pebbles of suitable size to become firmly wedged between them, thus throwing the wear upon the pebbles and prolonging the life of the lining to two or three times that of steel or silex.

In operation, when a pebble becomes fractured or worn and escapes from the place in which it was held, another will take its place and the effect is to maintain what is practically a flint lining to the mill. The rough surface presented entirely avoids the tendency

of the whole charge to skid on the lining with the consequent great wear of the latter and small crushing efficiency.

The illustration showing the sections of this lining will make the construction clear without much explanation. One of the plain sections is shown and also a liner for the manhole cover, as well as one of the sections abutting the manhole. They are attached to the shell of the tube mill by bolts, the entire relining can be done by ordinary unskilled labor, and the mill need not be out of operation over twenty-four hours. Experiments at El Oro, where seventeen tube mills are in operation, demonstrated the superiority of this lining on all points of comparison, and it has fully met all that was expected of it since its installation in other mills.

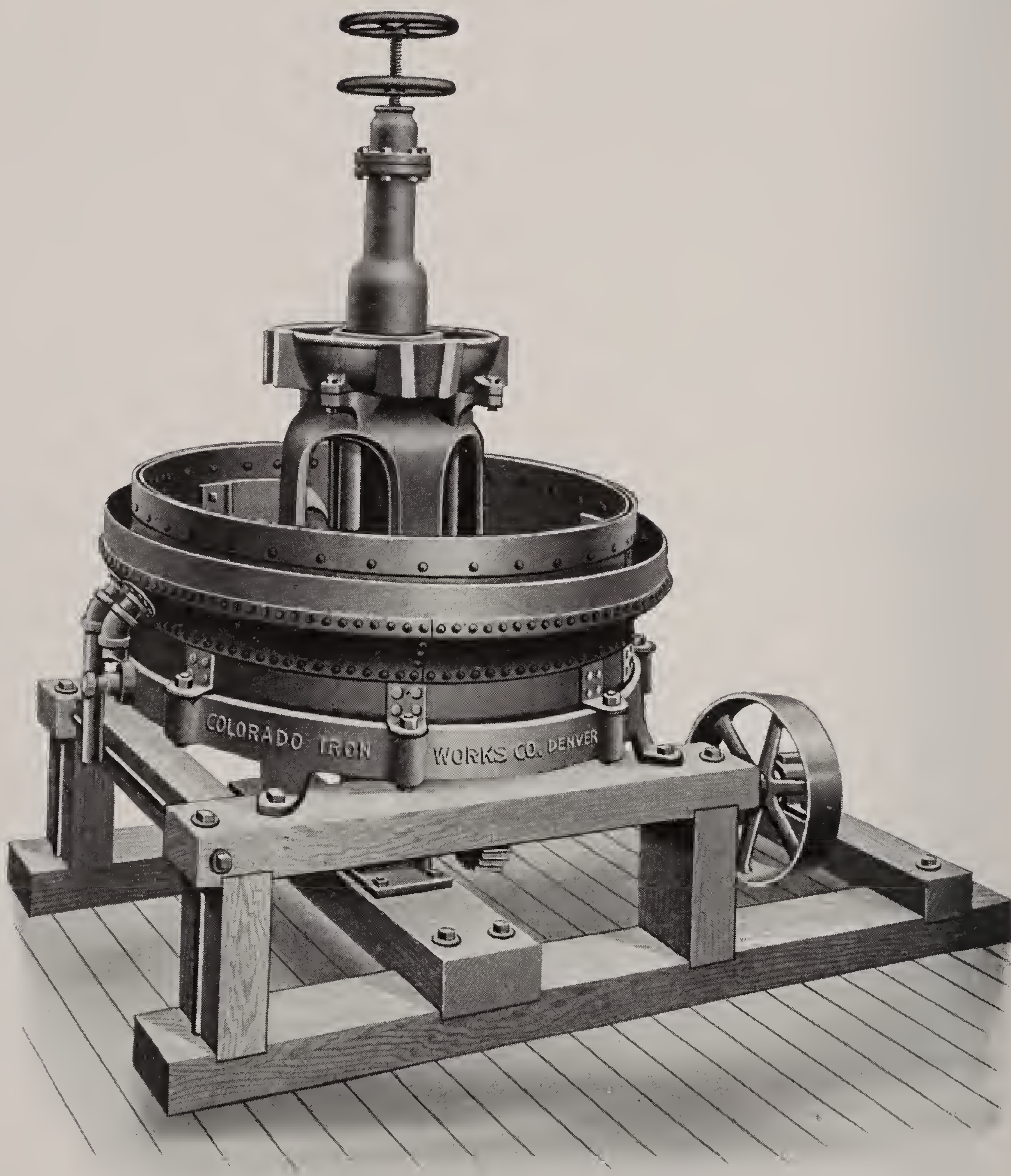
The manner in which the pebbles lodge in the grooves is a matter of surprise to those who have never seen it, as may be judged from



INTERIOR VIEW OF TUBE MILL WITH EL ORO LINING.

the illustration on this page, which is reproduced from a photograph of the interior of a tube mill which had been in operation for two months. El Oro tube mill lining may be successfully used in any tube mill with flint pebbles for either wet or dry grinding.

We manufacture El Oro lining under special license from the owners of the patents, who have wisely established a royalty charge so low as to leave a large margin of saving for tube mill users. This charge is in the form of a payment per pound weight of lining, which we include in our price, there being no further charge to the user by reason of the patent.



CONTINUOUS GRINDING PAN.

Grinding Pans.

The recent tendency toward the exclusive use of tube mills for fine grinding has caused many to lose sight of the good qualities of properly constructed pans. It is true that most competitive tests have shown results in favor of the tube mills, but the results have not been so conclusive as to indicate the passing of grinding pans, and those having difficult transportation problems to contend with, as well as those operating small plants, are fortunate in having in grinding pans the means of closely approaching if not equalling the economy of regrinding with tube mills.

The illustration on the opposite page shows our latest improved continuous feed and overflow grinding pan, a number of which we have supplied to cyanide plants, and which we believe to be superior to any elsewhere obtainable. It is five feet in diameter, with shoes and dies of form similar to those of the Wheeler amalgamating pan, but in all its features designed and constructed with special reference to the requirements of regrinding in cyanide work.

The pulp for regrinding is led into an annular feed box surrounding and attached to the upper part of the driver and passes downward through four pipes to the inner edges of the mullers. In the upper edge of the curb an annular space will be seen, which is intended to receive a continuous strip in order to secure the desired height of curb. Wood or lead is used for this, as the overflow can then be made level independently of the bottom of the pan.

The discharge is over the edge of the curb into the launder surrounding the pan and the height of the curb together with the amount of water supplied regulates the fineness of product, more water being used for a given size with a high curb than with a low one. Three equidistant plows held in sockets attached to the inner surface of the curb serve to agitate the pulp and direct it toward the center. The dovetail sockets on the outer edge of the feed box are for compensating weights not shown in place in the illustration.

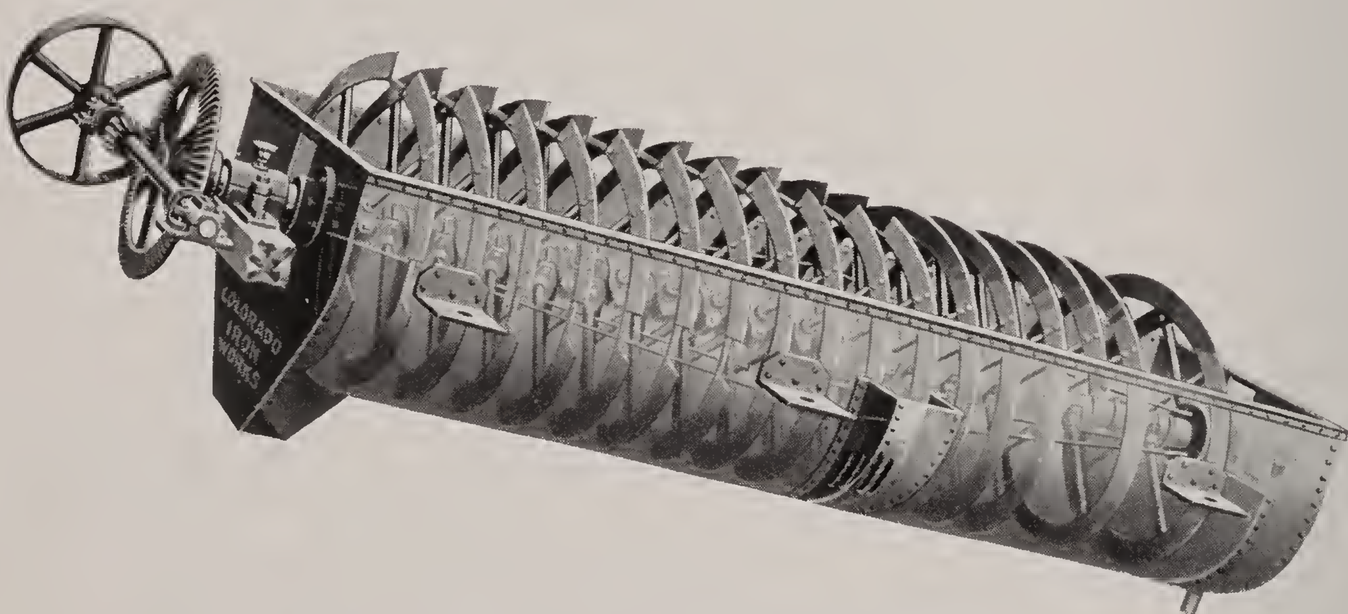
The weight of these pans without the timber framing is 7,500 pounds each.

The Akins Classifier.

(Patented)

The separation of sand from slime is an essential step in almost all methods of cyanidation but one which cannot be said to have been satisfactorily accomplished until the advent of mechanical classifiers and even then, until the Akins classifier was placed upon the market, the means available were far from all that could be desired in simplicity and freedom from attention by those operating them.

The Akins classifier consists of a trough enclosing a revolving helix. The trough, which is set with an inclination downward toward the slime discharge, has at one end an overflow weir and hopper for the slime and water product, and at the other end a discharge hopper for the sand product. Revolving within the trough is a shaft carry-



45 IN. BY 13 FT. AKINS CLASSIFIER.

ing a single, continuous helix or spiral at the overflow end for part of the length and a double interrupted helix or spiral for the balance of the length of the trough. The feed inlet is so placed that the pulp is led into the trough below the surface of the charge. The spiral is gear-driven and revolves at from three to five revolutions per minute.

In operation the thin pulp entering the feed box meets the slowly moving spiral, the heavier solids settle to the bottom of the trough and are gently advanced out of the surface of the charge toward the sand discharge end, the intermittent spiral permitting the contained moisture to flow back into the charge, the slow turning over of this sand washing the finest solids back and allowing the sand to dry

or give up all moisture except that held by capillary attraction. The lighter solids suspended in the liquid flow over the weir into the collecting hopper, to the slime launder.

The machine is practically self-contained, and the only parts which require attention are the shaft journals which require oiling at long intervals. The spirals will last for years, as they move slowly and are only in contact with the sand a small part of the revolution.

The absence of cams, cranks, lifting devices, connecting rods with their connecting pins, shafts and bearings, all requiring lubrication, attention and renewals, has secured its ready acceptance by cyanide operators and its superior efficiency and flexibility of adjustment has been the cause of much enthusiasm on the part of users.

In practice it has never been found necessary to lift or dig out the spiral, even after the machine has been stopped, the pulp continuing to flow into the trough for a considerable time. When power is applied again, the spiral starts readily, without excessive strains, and in a few revolutions is working in a normal condition.

In addition to the separation of sand from slime the classifier is used in special cases for dewatering concentrates, and also in a continuous washing system for sands, in which three or more machines are placed in series, one above the other, the lower one in each case receiving the sand discharge from the one directly above, with the wash water or diluent, the overflow from the lowest being used as diluent for the one above. Thus while the dissolved value contained in the sand is being reduced, the overflow solutions are built up in value.

This arrangement offers a practical continuous system of washing sand and the elimination of the large intermittently operated tanks now used. The method is not an experiment in any way, as it can be seen in successful operation in one of the largest milling plants in Colorado.

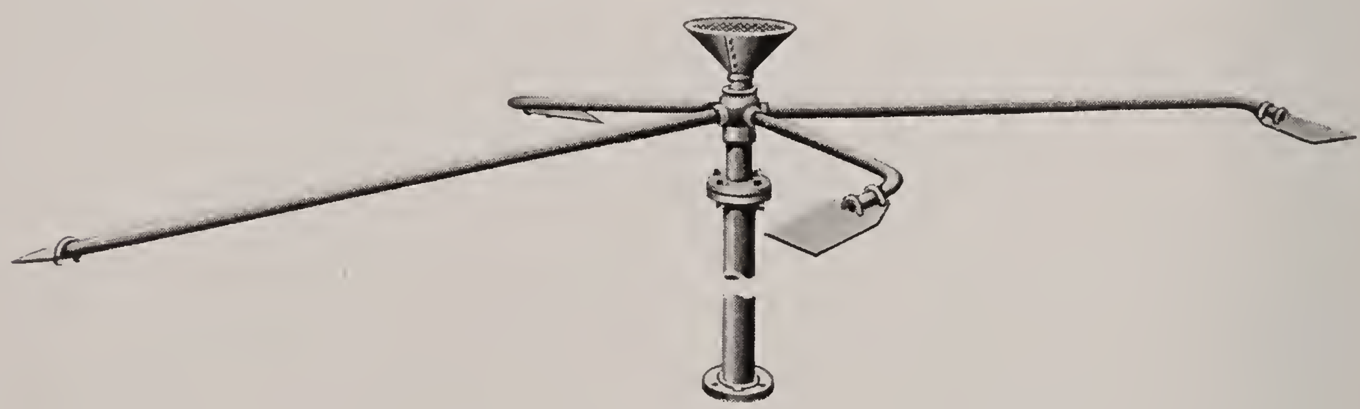
The success of the Akins classifier has been little short of phenomenal, considering the special nature of its work and the brief time which has elapsed since its introduction and we have rarely heard of a machine which has had such pronounced success from the start. We recommend it without reserve.

It is made in five sizes, 24 in. x 8½ ft., 30 in. x 10 ft., 36 in. x 12 ft., 45 in. x 13 ft. and 60 in. x 18 ft., the dimensions being the diameter of the helix and the length from the overflow weir to the edge of the sand discharge.

Distributors for Sand Tanks.

We have built a great many distributors for the automatic filling of sand tanks and have recently brought out the one shown below. This is by far the simplest ever devised, and by reason of its low cost there will rarely be any advantage in making one distributor, running on rails, serve for a number of tanks, as has heretofore been usual, except in the larger sizes.

The distributor revolves on a spindle extending downward into the top of the column and a sleeve which forms part of the bowl surrounds the bearing, very effectually excluding dirt. The deflecting plates on the ends of the pipes permit a nice adjustment for securing even distribution. The column which serves for the support of the distributor is made of a length suitable to the depth of the tank and



DISTRIBUTOR, STYLE C.

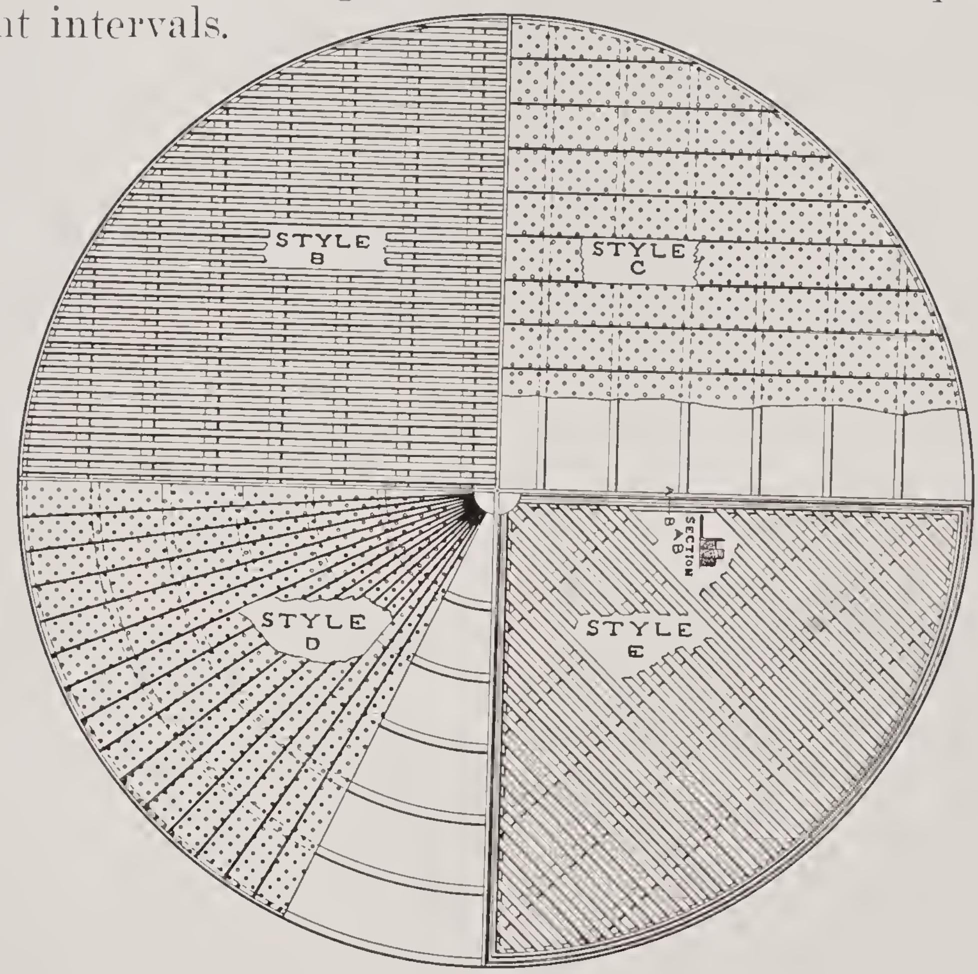
is permanently fastened to the center of the bottom. The moving part can be lifted out without the use of tools, and there is nothing in the construction to get out of order. This distributor incidentally solves the problem of head room, which so often presents itself in the installation of distributors running on a trolley. It is made and recommended for tanks up to 28 feet diameter. For tanks 30 feet and over in diameter we build distributors of another style.

As previously stated, the distributors shown are those of most general application; but upon receipt of information as to the conditions to be met we will recommend such as will best serve. Automatic distributors are greatly to be preferred to filling tanks by hand, even where labor is cheap, as the man directing the hose, although intelligent and careful, cannot produce such regular work.

Filter Bottoms.

We make various styles of filter bottoms, several different forms of construction being shown in the accompanying cut, styles "B" and "C," however, being the most favored. In style "B" the lower slats are spaced to suit the load on the grating strips above, and are notched on the bottom to permit the solution to flow to the outlet of the tank. The grating is made of one inch square pine, with spaces of one inch between the strips and a strip is placed around the outer edge of the grating, over which the filter cloth is laid and caulked with a rope in the annular space.

Style "C" is similar to "B," except that instead of the grating of one inch square pieces, this is formed of perforated boards cut to suit, the perforations being one inch in diameter and equally spaced at frequent intervals.

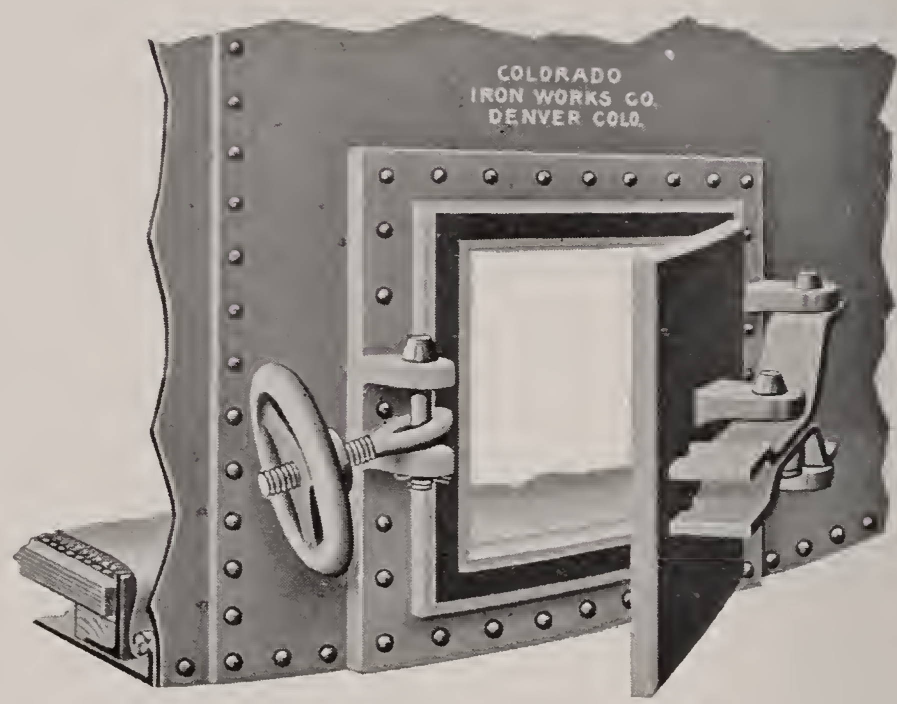


Style "D" is arranged to slope downwardly towards the center of the tank at from 3 degrees to 5 degrees from the horizontal. The supporting strips are cut in segments and spaced close enough to suit the load on the perforated floor above. This floor is similar to that used in style "C," except that it is in pieces that run radially. The supporting strips are notched on the under side to permit of the free flow of solution to outlet of tank.

Style "E" is the kind of filter frame used when the pneumatic system is put in the leaching tanks, and the air for agitation and oxidation passes through the filter and up through the mass of ore. This arrangement takes the place of the air headers and pipes sometimes used. The filter is made to slope towards the center of the tank in a manner similar to style "D".

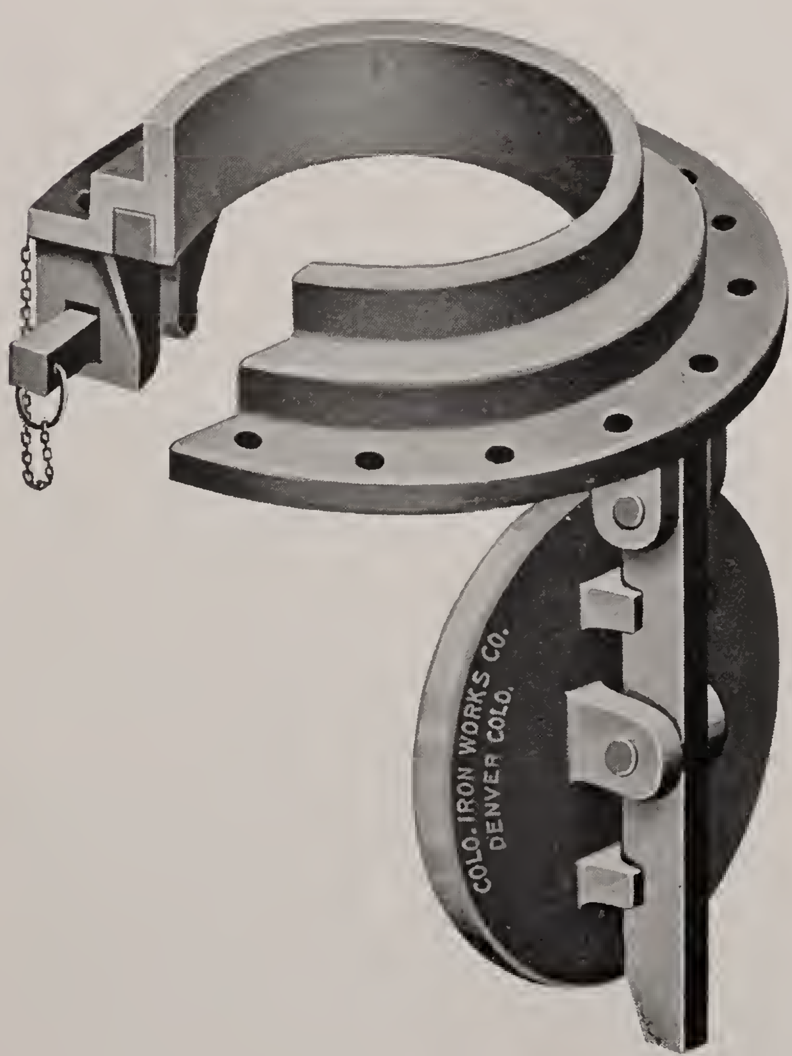
Discharge Gates and Doors.

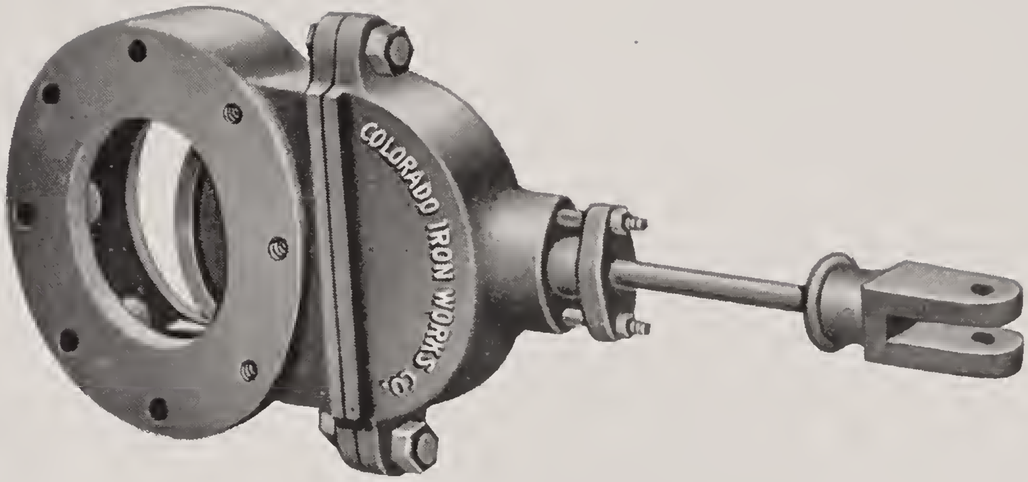
The square side discharge door here shown is of cast iron and is made to suit the curvature of the tank. The door seats against a rubber cushion and is fastened by means of a hand wheel as shown. We furnish this discharge door in the following sizes:



7x 7 in., weight 75 lbs.
10x10 in., weight 125 "
12x12 in., weight 165 "

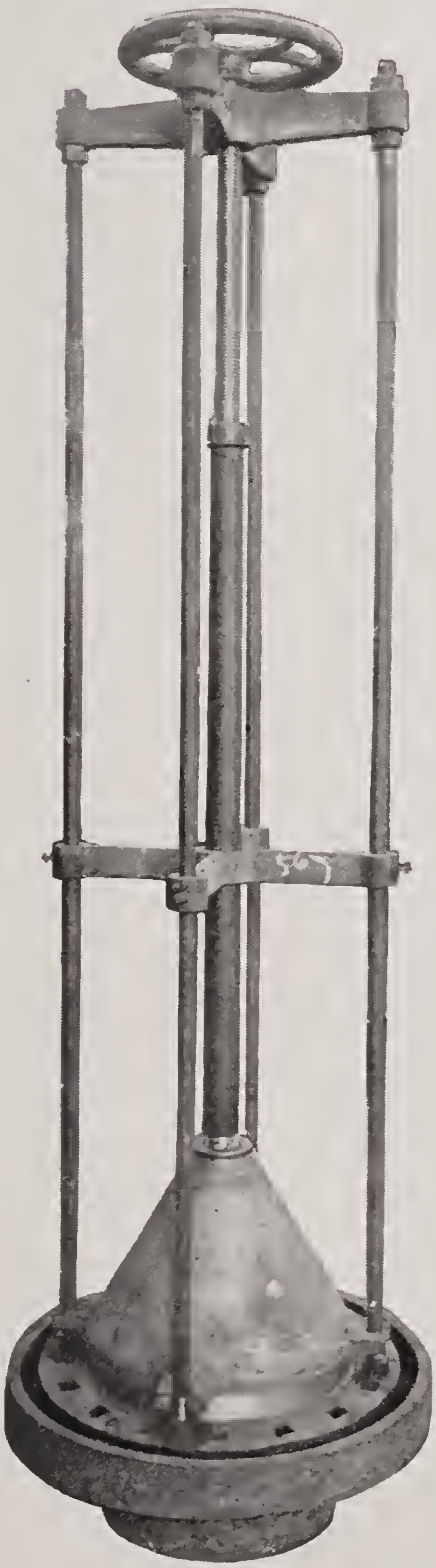
The style of bottom discharge gate, as shown in the lower illustration on this page, is made of cast iron, with a discharge opening of 12 inches, the steps in the casting being made to accommodate the filter frame and rope caulking space of the filter. A rubber gasket is inserted against which the swinging valve door seats, making a perfectly tight joint. The arrangement of this gate with the key permits of a quick and full opening, through which the charge is flushed into the tailings sluice underneath. The weight of this gate is 165 pounds, and it is one of the most practical styles of bottom discharge gates made.





QUICK OPENING GATE VALVE.

The above illustration shows one of a line of quick opening, all iron gate valves which we make especially for use in cyanide plants.



A comparison of the weights and dimensions given below with those of standard valves will show them to be of only about one-fourth the thickness and one-third the weight of the latter. The bodies of these valves are made of the same diameters as pipe flanges of corresponding sizes and they are attached by bolts passing entirely through the valve and adjacent flanges, except on the side toward the hood, where the holes are threaded for cap screws.

They are of ample strength and weight, and are thoroughly well fitted. They are especially recommended as an efficient and serviceable valve for slime tanks, where their small thickness will be welcomed on account of the material saving in head room.

SIZE	THICKNESS	WEIGHT
4 inch	3 inch	39 lbs.
5 inch	3 inch	45 lbs.
6 inch	3¼ inch	62 lbs.
7 inch	3¼ inch	79 lbs.
8 inch	3½ inch	103 lbs.
10 inch	3¾ inch	146 lbs.

The other illustration on this page shows our bottom discharge gate operated from the top of the tank. The valve is of cast iron and seats on a rubber gasket.

THE AKINS-ROTHWELL AGITATION TANK.

The Akins-Rothwell Agitation Tank.

(Patented)

In this agitation tank are avoided all of the difficulties incident to the operation of agitators as heretofore designed.

Agitation can be started after the charge has settled for any length of time, this being accomplished by means of the vertically movable central tube, which in practice is lowered when agitation is discontinued. Upon starting, the central tube is gradually raised and in a few minutes the entire contents of the tank can be brought into agitation. This feature has been proved thoroughly effective during about two years' use.

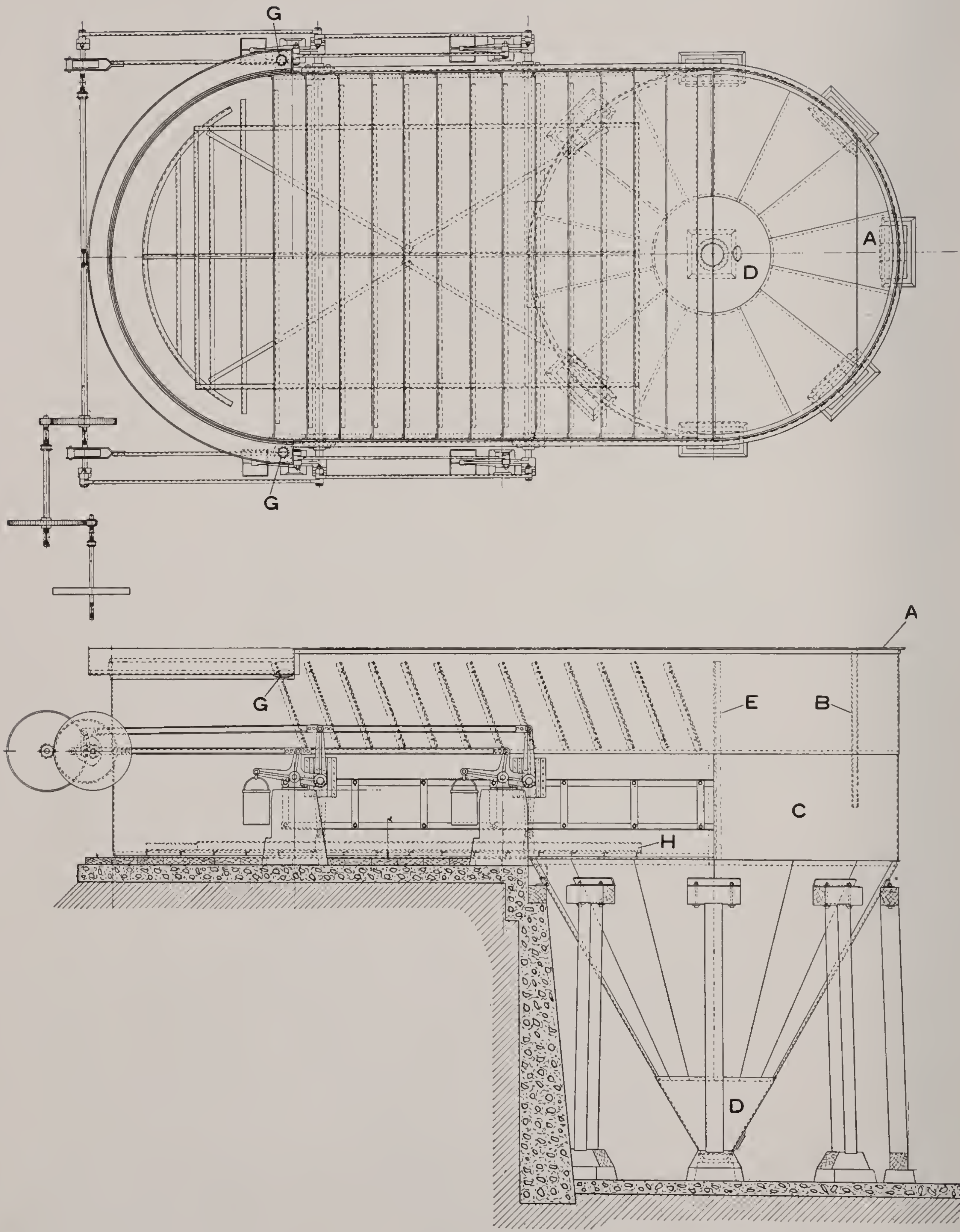
The tank is adapted to either compressed air agitation or agitation by means of a centrifugal pump. In the latter case, which is illustrated in the engraving herewith, the agitation tube is surrounded by a stationary tube having a rubber seat connection at the bottom and a trapped intake at the top, the pump suction being connected with the space between the two tubes. By this means none but the very finest solids pass through the pump and wear is practically eliminated.

At the top of the agitation tube a cone-shaped distributing apron is placed, over which the pulp flows evenly. Beneath this apron, but above the surface of the charge is a cutting vane so designed as to continuously withdraw pulp without favoring coarse or fine, solid or liquid, the opening in this cutting vane being adjustable to make the outflow equal to the inflow.

In the continuous method of agitation and circulation from tank to tank, the tops of all the tanks are placed substantially on a level, the circulation taking place through the cutting vanes. The duration of the agitation is governed by the size and number of tanks used and the rate of inflow into the system. As the last mentioned factor is fixed the time of agitation determines the size and number of tanks.

The tank can be used without the continuous circulation system and worked intermittently if desired. To agitate a charge under pressure, the tank is built with a dome top. The pump then being in a closed circuit, the pressure will balance, and agitation can be maintained without additional power.

Our patents on this tank are broad, and cover the movable inner tube, the outer tube with trapped inlet to keep coarse sand out of the pump, the cutting vane for continuously removing pulp of the same composition as that undergoing agitation in the tank as well as "a plurality of tanks, means for agitating the material in the tanks, and a vane for continuously drawing a definite proportional quantity of liquid containing agitated solids from one tank and delivering it to the next tank."



THE ROTHWELL CONTINUOUS THICKENER.

The Rothwell Continuous Thickener.

(Patented in U. S. and Foreign Countries.)

In the Rothwell Dewatering and Thickening Tank we present very decided improvements over anything heretofore used for like purposes. Its use results in great economy of space and a considerable saving in cost of foundations over round tanks of like capacity. It has all the advantages of the cone tank for collecting the settled solids, to which is added a very large settling area, with slow-moving current for the settling of the very finest solids. A very high efficiency is secured by the length through which the liquid flows from the feed compartment to the overflow end, together with the greatly enhanced settling effect, produced by the inclined baffles.

In the drawing the inflow is shown at A, between the vertical baffle B and the end of the tank. The top of this baffle is level with the top of the tank and extends about three-fourths of the depth of the main body of the tank, thus the whole feed passes to this depth and distributes into the first settling part C. The heaviest of the solids settle direct into the cone D, the lighter solids passing through the perforated plate forming the lower part of the baffle E, the top of which is about six inches below the top of the tank, so that a constant surface flow passes over the top of it and the inclined baffles. The very lightest of the suspended solids, when they settle into the spaces between the inclined baffles are removed from all disturbing influences. The effective settling area is thus equal to a tank of very much larger dimensions. The overflow weir is of soft metal, wood or belting, so that it can easily be brought to a uniform level. The clear overflow passes through the opening G in the collecting launder to the storage or other tank.

The solids that settle to the floor of the main tank are moved to the collecting cone by the slowly-moving reciprocating conveyor H. The motion of the rake is forward on the bottom of the tank, at the end of the forward stroke it rises about three inches and returns to the other end of the stroke, when it descends to the floor of the tank again, thus slowly moving the solids that have settled toward the cone.

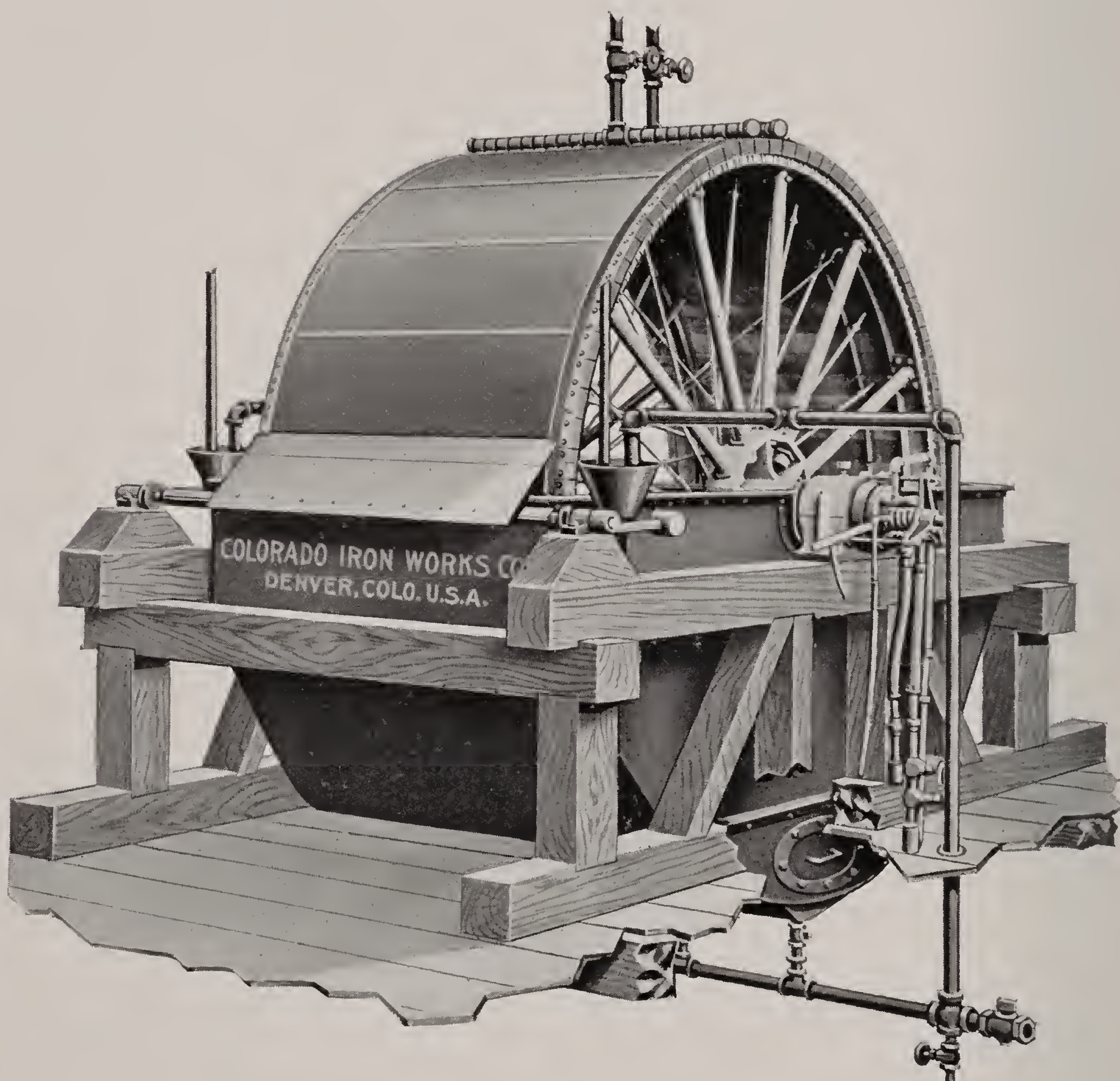
The power required to move the rake is very small, about one-eighth horsepower being ample for regular work on the largest size tank. When double-end tanks are used, the method of operating is the same except that the feed is central over the cone.

We issue a special pamphlet describing this machine.

The Portland Continuous Slime Filter.

(Patent Pending.)

The Portland filter has long since passed the experimental stage and its success has been so uniform that we unhesitatingly recommend it. Its work is in all respects equal to that of any other filter on similar ores and its advantages are such as to make it by far the most attractive filter to be obtained.



THE PORTLAND CONTINUOUS SLIME FILTER.

The great superiority of the revolving filter arises principally from the fact that it forms a thin cake, easily and thoroughly washed with a minimum amount of solution and water. A thin cake can be formed very rapidly and, being continuously removed as fast as formed, the capacity per unit of filtering area is very great. The time during which any section is submerged is only about three minutes, as against three-quarters to two hours with submerged leaf filters forming a ¾-inch to ⅞-inch cake. The time consumed in

washing is equally favorable to the leaf filters, and, owing to the thicker cake, channeling takes place and the washing is less thorough.

The continuous operation of the revolving filter is in itself a great advantage over machines of the leaf type, which are of necessity operated intermittently and require considerable attention. In strong contrast to this is the automatic action of the revolving drum type, which works continuously without attention, other than to look it over at intervals of two hours or so to see that everything is working properly. The drum type of filter has a decided advantage over the submerged leaf type in point of space occupied for a given tonnage capacity, and in initial cost of installation.

The drum is divided into twenty-two independent sections, each covered with the filtering medium and connected by a pipe with the valve which controls the loading, washing and discharge of the cake. There are four ports in the valve, three under vacuum and one under compressed air. The latter is for the blow at discharge, while of the three vacuum ports, one is connected with the submerged portion of the drum, the next with the ascending side, where the washing is done with weak solutions, and the third with the descending side, which is subjected to the water wash. The construction is the simplest conceivable, one pipe from each section serving for loading, washing with solution, washing with water and discharging, and but one pipe from the valve for each solution drawn off, and one for the blow.

During revolution, nine sections are immersed in the pulp and the vacuum draws a thin, even cake on the filter medium. Each section of the drum, rising out of the pulp, soon meets the wash solution coming down in a thin film from above. As it passes the top, this is changed to water, which is flowed on in a film which is so adjusted that it is all drawn through the cake just before it passes the point at which the suction is changed to the blow which disengages the cake. While all these solutions, air and vacuum pass through the single pipe connection with the filter section, the effect of the valve is to make a separate delivery of each solution so that it can be led to its appropriate tank. The cycle of loading, washing and discharging is therefore continuous and the entire operation from the maintenance of the pulp level in the tank to the final discharge of the washed cake and delivery of the three solutions is entirely automatic.

When the preliminary grinding is done in water the machine is also used for the dewatering of the slime from thickening tanks, preparatory to treatment in cyanide solutions, when the continuous method of the treatment of an ore by the cyanide process is used.

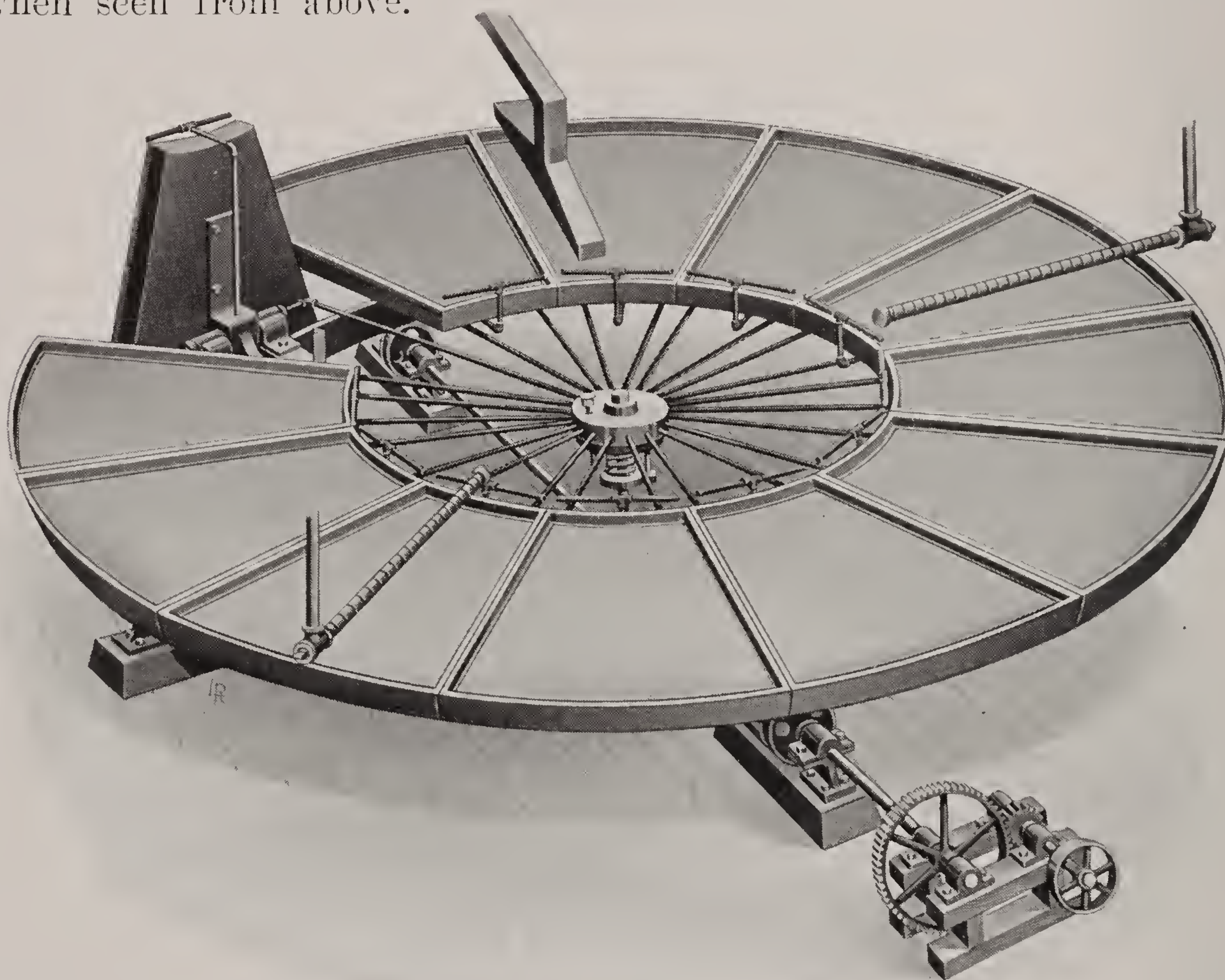
The filter is built 12 and 14 feet diameter and from 5 to 14 feet width of face as required for capacities up to 120 tons per 24 hours.

The Rothwell Sand and Slime Filter.

(Patented.)

The Rothwell horizontal pan sand and slime filter is designed to handle pulp carrying a large proportion of crystalloid or fine granular product, such as it would be impossible to load on other filters. It is extremely simple in construction, automatic in operation and easily kept in continuous service without interruption for removal of the filter medium.

The method of operation can readily be understood by reference to the illustration, the machine as shown revolving clock-wise when seen from above.



THE ROTHWELL SAND AND SLIME FILTER.

The pulp to be filtered is loaded into the pan passing under the feed distributor, to a depth of one or two inches. As soon as the pan has passed the loading point, the conduit leading from beneath the filter medium to the central control valve registers with the first vacuum port, the degree of vacuum maintained in this port being determined by trial to leave a porous bed of solids.

As soon as the liquid contained in the pulp is drawn through, the vacuum is cut out automatically and the pan loaded with wash solution or water, the conduit then registering with the second vacuum port through which this wash is drawn. A second wash is applied

in like manner and drawn through the third vacuum port. The vacuum for these three ports is separately adjusted for the class of pulp handled, after which it remains fixed as long as conditions remain unchanged, separate delivery of the solution and washes being made if desirable.

After the pan has completed the loading, washing and drying parts of the cycle, it is tilted automatically to a position beyond the vertical, and air under pressure is admitted beneath the filter medium through the conduit and a port in the valves. This air pressure loosens the cake of solids and at the same time it is applied a washing pressure port of the central valve registers with a separate conduit and a spray of water or air is blown across the upper surface of the filter medium, clearing off any solids not discharged by the under blow. The pan now automatically resumes the horizontal position and passes under the feed distributor where it receives a fresh charge, the other pans having meanwhile gone through the same cycle of operations, the action is practically continuous.

This filter should fill the want for a continuous machine capable of handling that large class of ore pulps in which the proportion of fine sands is too great to permit of loading satisfactorily on filters of the submerged leaf or revolving drum type. Like the Portland filter, its operation is free from the numerous disadvantages of the submerged leaf filters, particularly in the matters of attention required and the pumping of large volumes of pulp, solutions and water which form such important items in the high cost of filtration by the older methods.

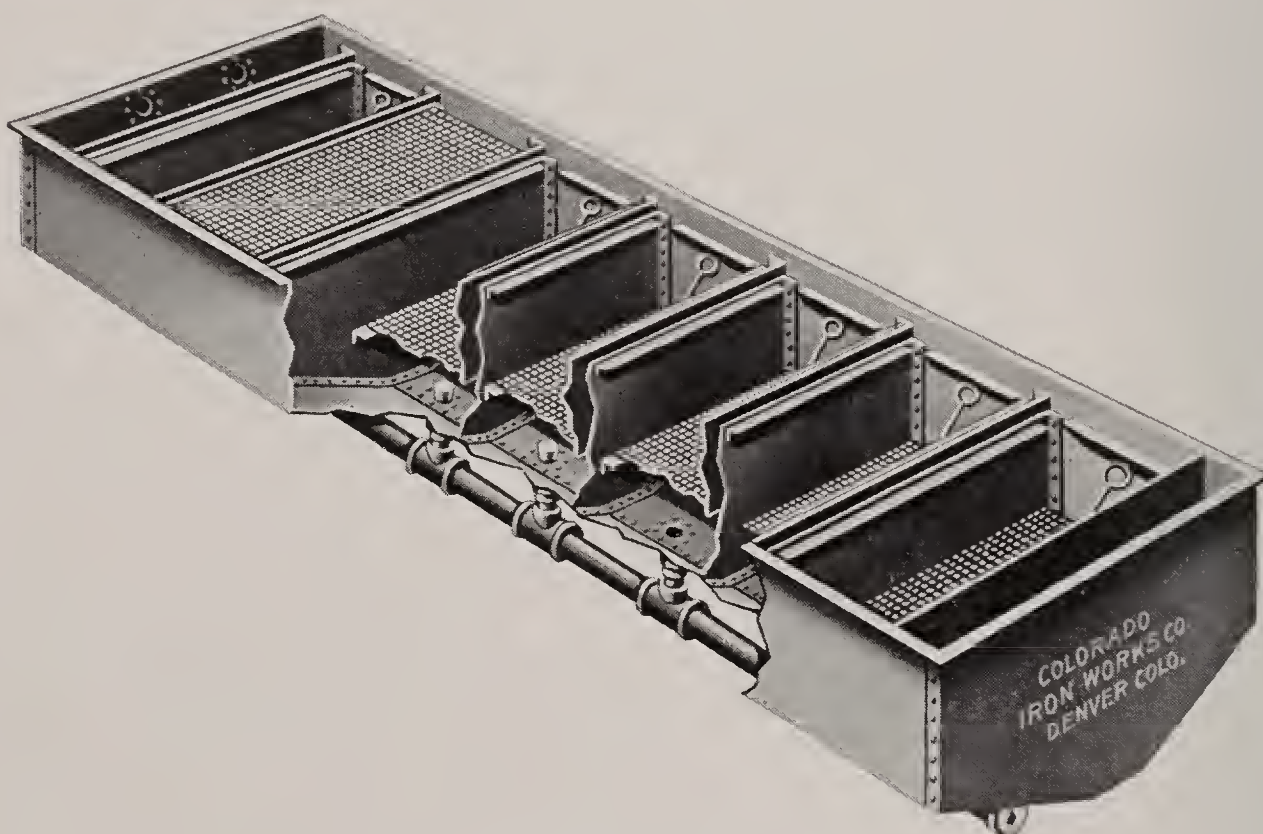
The valve is mechanically the same as that which has proved so successful in the Portland filter, with such changes in the location of ports as are necessary to accomplish the special results desired. There is great latitude in the matter of adjustments to secure the most advantageous action at every point of the cycle and for this reason this machine has greater adaptability than any other.

The pans are light and substantial and are interchangeable, and as renewals are confined entirely to the replacement of the filter medium, a few extra pans enable the machine to be maintained in the most efficient condition practically without interruption. The life of the filter medium depends on the pulp being handled, but will be as great as in any other filter, and as it is made up of cheap standard materials the cost is low.

The power required for a 20-foot diameter machine making four to six revolutions per hour, is about one and one-half horse power and the capacity is very high. The driving mechanism, and, in fact, the entire machine, is extremely simple and there are no complicated or delicate adjustments to be made. Either the wet or dry vacuum can be used.

Precipitation Boxes.

For effecting precipitation by zinc shavings, boxes of various designs have been used, those here illustrated being such as have gained special favor among practical cyanide men. The superiority of steel over wood in the construction of zinc boxes is well settled, their freedom from leakage and permanence being strong points in their favor as well as the facility of making a thorough clean up. In addition to their other disadvantages, the wooden precipitation boxes absorb more or less of the values in solution and their crevices offer lodgement for precipitate.



STANDARD STEEL ZINC BOX.

Our standard steel precipitation box is shown above. This is used in medium size and large plants, the number depending upon the capacity required. The solution enters the box through the narrow compartment shown nearest the observer in the illustration, and rises through the first wide compartment. The overflow from each large compartment is into a narrow one which directs the solution beneath the screen of the larger compartment next following, the barren solution finally rising in a narrow compartment at the farther end and leaving the box through pipes.

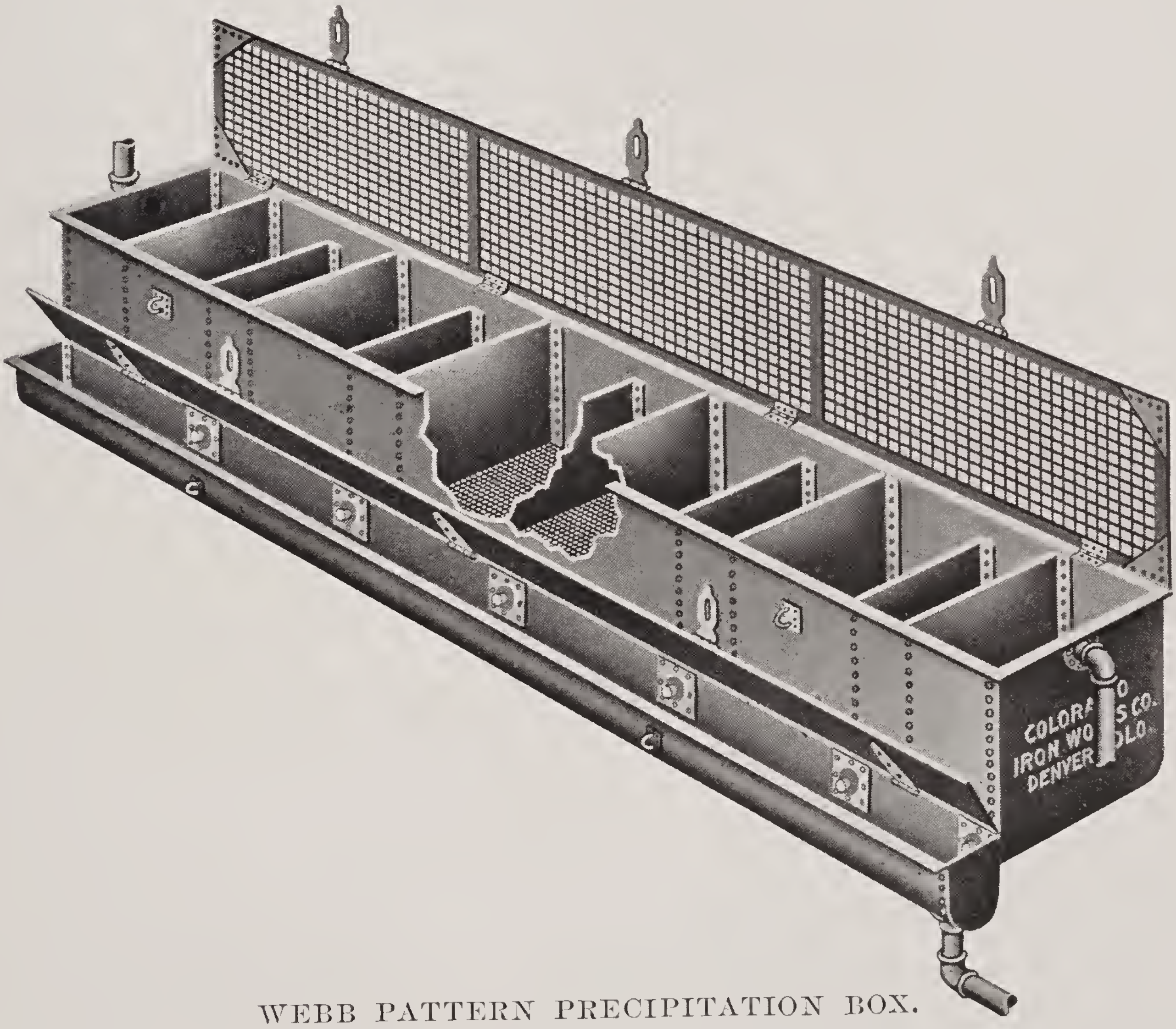
The holes leading to the pipe below the box are closed by rubber stoppers which are removed at the clean up and the precipitate flushed into a tank.

The total weight of this zinc box is about 1,000 pounds, and the

capacity of that part of each large compartment which is filled with zinc shavings, about 7½ cubic feet.

The Webb type of zinc box is shown below. In this box it is sought to take advantage of increased precipitating power due to electrolytic action arising from a carbon-zinc couple, brought about by filling the compartments alternately with charcoal and with zinc shavings.

Referring to the illustration, the solution enters at the farther end, flowing downward through charcoal and being directed upward through the next compartment containing zinc shavings, this being continued throughout the length of the box, the barren solution leaving through a pipe near the top of the lower end.



WEBB PATTERN PRECIPITATION BOX.

Of the twelve compartments, six, for charcoal, have a capacity of 1½ cubic feet each, and six, for zinc shavings, have a capacity of 1¾ cubic feet each. In many cases where boxes of this type are used, all the compartments are filled with zinc shavings, but this offers the disadvantage of passing the solution downward through the zinc in half of the compartments and the box then becomes but an inferior substitute for our standard box.

The clean up is made by removing the rubber stoppers which are shown within the trough at the side, and flushing out the precipitate through the trough and pipe in its end. Weight about 800 pounds.

Individual zinc boxes are the most convenient for small plants, but sizes larger than those here shown sometimes are used in large installations. Only the uppermost boxes are cleaned up, those occupying the middle and lower positions being advanced to the upper end and the boxes which have been cleaned up and filled with fresh zinc placed at the lower end of the series. By this means clean zinc is brought into contact with the weakest solution, and while this is also accomplished in boxes of the multiple compartment form, by transferring zinc from lower to upper compartments, it is necessary to handle the contents of all the compartments. However, this presents the opportunity to place a layer of fresh zinc at the bottom before returning the old zinc, which largely prevents the "shorts" from passing through the screen.

ROUND INDIVIDUAL ZINC BOXES.

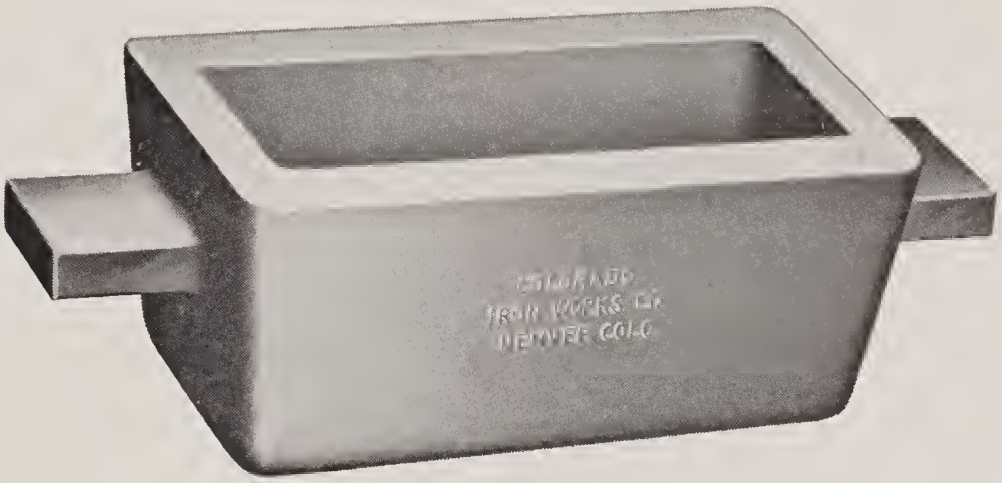
In the round boxes, the solution is led below the false bottom by a pipe passing down the center, and passes upward through the zinc shavings, discharging through a pipe in the side near the top. In service, the pipes are joined by unions as shown. The capacity of the round box illustrated is about 1 3/5 cubic feet and the weight about 55 pounds.

SQUARE INDIVIDUAL ZINC BOXES.

The square boxes are of simple construction and require no explanation. The one illustrated has about one cubic foot capacity and weighs about 30 pounds.

Bullion Moulds.

Our bullion moulds are made of a fine grade of close-grained iron, free from imperfections of all kinds, are trimmed out and have smooth and true surfaces.



SIZES AND CAPACITIES OF BULLION MOULDS

Length Inches	Width Inches	Depth Inches	Capacity in Ounces		Weight Lbs.
			Gold	Silver	
3½	1	1	20	10	2
3½	1½	1½	50	25	2¼
4	2	2	100	56	4½
5½	2½	2½	250	140	8
6½	3¼	3¼	500	275	14
9	3¾	3¾	1,000	550	25
11	4¾	4¾	2,000	1,100	50
11½	5¼	4½	2,500	1,350	55
12	7	6	5,000	3,000	110

Conical Slagging Moulds.

These moulds are made very heavy and are finished inside. They are about 14 inches in diameter and 12 inches high over all. The base and rim are the same diameter, so they can be rolled about on the floor. The capacity when filled within one-half inch of the top is somewhat over a gallon, and the weight is 200 pounds.

Steel Tanks.

The advantages of steel tanks over wooden tanks are so many and important that they greatly outweigh any considerations of relative first cost. We make steel tanks of all kinds used in cyanide work, including lead lined tanks for acid treatment. We manufacture all the special fittings and attachments, some of which are illustrated and described in this catalogue, which enter into the completed tanks as used in the application of the cyanide process to ores. Our experience in this line has been very large and our familiarity with all the requirements enables us so to design and construct them as most fully to attain the desired results in operation.

On the opposite page we present a table showing the capacities of tanks of various sizes, hoping these data may be of assistance in making preliminary estimates of the sizes and number of tanks required, as well as in the operation of the plant.

The figures given are for U. S. gallons of 231 cubic inches and short tons of 2,000 pounds. For imperial gallons the figures should be multiplied by .8333, and for long tons of 2,240 pounds, the figures for short tons should be multiplied by .8928. The figures representing tons of sand are based on 25 cubic feet per ton, which is arbitrary, as the capacity of tanks will vary from this if the specific gravity differs from that which is assumed, and will also vary between wide limits according to the manner of charging, whether wet, moist or dry.

The capacities of sizes other than those listed can readily be ascertained by remembering that the areas vary as the square of the diameters; that is, a tank having a diameter twice as great as a given tank will have four times the capacity. The figures representing cubic feet also equal the area of the bottom of the tank, in square feet. In estimating the capacity of a sand leaching tank, about six inches should be allowed for the filter bottom and about six inches for the rim of the tank to extend above the point to which it is intended to be filled.

The capacity of a conical tank is one-third that of a cylindrical tank of the same diameter and height; therefore, to find the total capacity of a cone-bottom tank, take the capacity of the cylindrical part from the table and add one-third of the capacity of a cylindrical tank having the diameter of the largest part of the cone and a height equal to the perpendicular distance from the rim to the apex.

Capacities of Tanks.

Diameter Ft.	Diameter In.	Per Foot Depth: Cubic Feet	Per Foot Depth: Gallons	Per Foot Depth: Tons Water	Per Foot Depth: Tons Sand*	Per Inch Depth Tons Water	Diameter Ft.	Diameter In.
4	0	12.57	93.97	.39	.50	.033	4	0
4	6	15.90	118.93	.50	.64	.041	4	6
5	0	19.64	146.83	.61	.79	.051	5	0
5	6	23.76	177.67	.74	.95	.062	5	6
6	0	28.27	211.44	.88	1.13	.074	6	0
6	6	33.18	248.15	1.03	1.33	.086	6	6
7	0	38.48	287.80	1.20	1.54	.100	7	0
7	6	44.18	330.38	1.38	1.77	.115	7	6
8	0	50.27	375.90	1.57	2.01	.131	8	0
8	6	56.75	424.36	1.77	2.27	.149	8	6
9	0	63.62	475.75	1.98	2.55	.165	9	0
9	6	70.88	530.08	2.22	2.84	.185	9	6
10	0	78.54	587.35	2.46	3.14	.205	10	0
10	6	86.59	647.55	2.71	3.46	.225	10	6
11	0	95.03	710.69	2.97	3.80	.248	11	0
11	6	103.87	776.77	3.25	4.16	.271	11	6
12	0	113.10	845.18	3.54	4.52	.295	12	0
13	0	132.73	992.62	4.14	5.31	.345	13	0
14	0	153.94	1,151.21	4.81	6.16	.401	14	0
15	0	176.72	1,321.54	5.52	7.07	.460	15	0
16	0	201.06	1,503.62	6.28	8.04	.524	16	0
17	0	226.98	1,697.45	7.09	9.08	.591	17	0
18	0	254.47	1,903.02	7.92	10.18	.660	18	0
19	0	283.53	2,120.34	8.86	11.34	.738	19	0
20	0	314.16	2,349.41	9.82	12.57	.818	20	0
21	0	346.36	2,590.22	10.82	13.85	.902	21	0
22	0	380.13	2,842.79	11.88	15.21	.990	22	0
23	0	415.48	3,107.10	12.98	16.62	1.082	23	0
24	0	452.39	3,383.15	14.14	18.10	1.178	24	0
25	0	490.88	3,670.95	15.34	19.64	1.278	25	0
26	0	530.93	3,970.50	16.56	21.24	1.380	26	0
27	0	572.56	4,281.80	17.89	22.90	1.491	27	0
28	0	615.75	4,604.85	19.24	24.63	1.604	28	0
29	0	660.52	4,939.64	20.64	26.42	1.720	29	0
30	0	706.86	5,286.18	22.09	28.27	1.841	30	0
32	0	804.25	6,014.48	25.13	32.17	2.094	32	0
34	0	907.92	6,789.80	28.37	36.32	2.364	34	0
36	0	1,017.88	7,612.08	31.69	40.72	2.641	36	0
38	0	1,134.12	8,481.36	35.44	45.36	2.953	38	0
40	0	1,256.64	9,397.64	39.27	50.27	3.273	40	0
42	0	1,385.45	10,360.88	43.30	55.42	3.608	42	0
44	0	1,520.53	11,371.16	47.52	60.82	3.960	44	0
46	0	1,661.91	12,428.40	51.94	66.48	4.328	46	0
48	0	1,809.56	13,532.60	56.55	72.38	4.712	48	0
50	0	1,963.50	14,683.80	61.36	78.54	5.113	50	0

* Figures for tons of sand are based on 25 cubic feet per ton.

Equivalent Rates of Flow of Water.

Tons per 24 Hours	Tons per Hour	Cu. Feet per Hour	Cu. Feet per Minute	Gallons per Hour	Gallons per Minute
1	.042	1.337	.0223	10	.1667
2	.083	2.674	.0446	20	.3333
3	.125	4.010	.0668	30	.5000
4	.167	5.347	.0891	40	.6667
5	.208	6.684	.1114	50	.8333
6	.250	8.021	.1337	60	1.000
7	.292	9.358	.1560	70	1.167
8	.333	10.69	.1782	80	1.333
9	.375	12.03	.2005	90	1.500
10	.417	13.37	.2228	100	1.667
20	.833	26.74	.4456	200	3.333
30	1.25	40.10	.6684	300	5.000
40	1.67	53.47	.8912	400	6.667
50	2.08	66.84	1.114	500	8.333
60	2.50	80.21	1.337	600	10.00
70	2.92	93.58	1.560	700	11.67
80	3.33	106.9	1.782	800	13.33
90	3.75	120.3	2.005	900	15.00
100	4.17	133.7	2.228	1000	16.67
200	8.33	267.4	4.456	2000	33.33
300	12.5	401.0	6.684	3000	50.00
400	16.7	534.7	8.912	4000	66.67
500	20.8	668.4	11.14	5000	83.33
600	25.0	802.1	13.37	6000	100.0
700	29.2	935.8	15.60	7000	116.7
800	33.3	1069.	17.82	8000	133.3
900	37.5	1203.	20.05	9000	150.0
1000	41.7	1337.	22.28	10000	166.7

EXAMPLE—To find the flow in gallons per minute equal to 85 tons per day, add the figures for 80 and for 5 tons thus: 13.33+.833=14.16 gallons per minute.

All figures are based on U. S. gallons of 231 cubic inches and tons of 2,000 pounds.

Tons per day÷6=gallons per minute.

Equivalent Rates of Flow of Water.

Gallons per Minute	Gallons per Hour	Cu. Feet per Minute	Cu. Feet per Hour	Tons per Hour	Tons per 24 Hours
1	60	.134	8.021	.25	6
2	120	.267	16.04	.50	12
3	180	.401	24.06	.75	18
4	240	.535	32.08	1.00	24
5	300	.668	40.10	1.25	30
6	360	.802	48.13	1.50	36
7	420	.936	56.15	1.75	42
8	480	1.069	64.17	2.00	48
9	540	1.203	72.18	2.25	54
10	600	1.337	80.21	2.50	60
20	1200	2.674	160.4	5.00	120
30	1800	4.010	240.6	7.50	180
40	2400	5.347	320.8	10.0	240
50	3000	6.684	401.0	12.5	300
60	3600	8.021	481.3	15.0	360
70	4200	9.358	561.5	17.5	420
80	4800	10.69	641.7	20.0	480
90	5400	12.03	721.8	22.5	540
100	6000	13.37	802.1	25.0	600
200	12000	26.74	1604.	50.0	1200
300	18000	40.10	2406.	75.0	1800
400	24000	53.47	3208.	100.	2400
500	30000	66.84	4010.	125.	3000
600	36000	80.21	4812.	150.	3600
700	42000	93.58	5615.	175.	4200
800	48000	106.9	6417.	200.	4800
900	54000	120.3	7218.	225.	5400
1000	60000	133.7	8021.	250.	6000

EXAMPLE—To find the number of tons per day equivalent to 73 gallons per minute, add the figures for 70 and for 3, thus: 420+18=438 tons per day.

All figures are based on U. S. gallons of 231 cubic inches and tons of 2,000 pounds.

Gallons per minute×6=tons per day.

Slime Density Relations.*

The table is based on the percentage of solid in the slime, opposite which is given the ratio of solid to liquid. The numbers heading the double columns following, are the specific gravities of the dry solid (that of water being taken as unity). The columns headed S. G. show the specific gravities of the slime, that of water being taken as 1000; that is, the figures show directly the weight of a liter of slime in grams. The columns headed Vol. show the number of cubic feet of the slime in one ton of 2000 pounds.

The specific gravities of solids chosen will probably cover the range of slimes ordinarily met with and the intervals are sufficiently small to admit of interpolation without appreciable error. The last column (4.50) is a hypothetical concentrate and is the specific gravity of a mixture of 80 per cent. pyrite and 20 per cent. quartz. The average specific gravity of working cyanide solutions is so small as to be negligible.

The table is convenient for ascertaining the amount of solid and of solution in slime pulps from the number of cubic feet, determined by rod or float, in the tank; and specific gravity of the slime, determined by taking the weight of a liter or by a specific gravity indicator in the tank. It is useful in calculations for ascertaining the amount of solution to be abstracted or added in thickening and diluting, for correcting the strength of the solutions, for checking tonnage and for other purposes.

Assume that in a plant in which the specific gravity of the solid is 2.7, a tank is shown, by the depth of pulp in it, to contain 3530 cubic feet of pulp, a liter of which weighs 1223 grams. From the table it is found that the specific gravity 1223 corresponds to 26.16 cubic feet per ton and to 29 per cent. solid. The weight of pulp, therefore, is $3530 \div 26.16 = 135$ tons and the weight of solids $135 \times 0.29 = 39.15$ tons. The weight of solution is, by difference, 95.85 tons. If the solution titrates 1.05 pounds cyanide per ton and it is desired to bring the strength up to 2.5 pounds per ton, we have $2.5 - 1.05 = 1.45$ pounds cyanide to be added per ton. Therefore, $95.85 \times 1.45 = 139$ pounds cyanide to be added to the tank.

The table is useful in determining the sizes of tanks necessary for any given capacities. Thus, if it is desired to agitate 50 tons of dry slime (specific gravity of solid 2.6) with three parts solution, the table shows this to contain 25 per cent. solids and to have a volume of 27.08 cubic feet per ton; therefore, $50 \div 0.25 = 200$ tons of slime $\times 27.08 = 5416$ cubic feet, the required effective working capacity of the tank, to which an amount must be added to secure the desired height of curb above the charge.

*Metallurgical and Chemical Engineering, June, 1912.

Slime Density Relations.

Per Cent. Solids.	Ratio of Solids to Solution.	Specific Gravity of Pulp and Volume of One Ton in Cubic Feet, for Slimes Containing Solids of Different Specific Gravities.									
		2.50		2.60		2.70		2.80		2.90	
		S.G.	Vol.	S.G.	Vol.	S.G.	Vol.	S.G.	Vol.	S.G.	Vol.
5	1:19.000	1031	31.03	1032	31.01	1032	31.01	1033	30.97	1034	30.95
6	1:15.667	1037	30.85	1036	30.82	1039	30.79	1040	30.76	1041	30.74
7	1:13.286	1044	30.66	1045	30.62	1046	30.59	1047	30.56	1048	30.53
8	1:11.500	1050	30.46	1052	30.43	1053	30.39	1055	30.36	1055	30.32
9	1:10.111	1057	30.27	1059	30.23	1060	30.19	1061	30.15	1063	30.11
10	1: 9.000	1064	30.08	1065	30.03	1067	29.99	1068	29.95	1070	29.90
11	1: 8.091	1071	29.88	1073	29.83	1074	29.79	1076	29.74	1078	29.69
12	1: 7.333	1078	29.70	1080	29.64	1082	29.59	1083	29.53	1085	29.48
13	1: 6.692	1085	29.50	1087	29.44	1089	29.39	1091	29.33	1093	29.27
14	1: 6.144	1092	29.31	1094	29.24	1097	29.19	1099	29.12	1101	29.06
15	1: 5.667	1099	29.18	1102	29.05	1104	28.99	1107	28.91	1109	28.85
16	1: 5.250	1106	28.93	1109	28.85	1112	28.78	1115	28.71	1117	28.65
17	1: 4.882	1114	28.74	1117	28.65	1119	28.58	1123	28.50	1125	28.44
18	1: 4.556	1121	28.54	1125	28.45	1128	28.38	1131	28.30	1134	28.23
19	1: 4.263	1129	28.35	1133	28.26	1136	28.18	1139	28.09	1142	28.02
20	1: 4.000	1136	28.17	1140	28.06	1144	27.98	1147	27.89	1151	27.81
21	1: 3.762	1144	27.97	1148	27.87	1152	27.77	1156	27.68	1159	27.60
22	1: 3.545	1152	27.78	1157	27.67	1161	27.57	1165	27.47	1168	27.39
23	1: 3.348	1160	27.58	1165	27.47	1169	27.37	1174	27.27	1177	27.18
24	1: 3.167	1168	27.39	1173	27.27	1178	27.17	1182	27.06	1186	26.97
25	1: 3.000	1176	27.21	1182	27.08	1187	26.97	1191	26.85	1195	26.76
26	1: 2.846	1185	27.01	1190	26.88	1195	26.77	1201	26.65	1205	26.55
27	1: 2.704	1193	26.82	1199	26.68	1205	26.56	1210	26.44	1215	26.84
28	1: 2.571	1202	26.62	1209	26.49	1214	26.36	1220	26.24	1224	26.13
29	1: 2.448	1211	26.43	1217	26.29	1223	26.16	1229	26.03	1234	25.92
30	1: 2.333	1220	26.24	1226	26.10	1233	25.95	1239	25.83	1244	25.71
31	1: 2.226	1229	26.05	1236	25.90	1242	25.75	1249	25.63	1255	25.50
32	1: 2.125	1238	25.86	1245	25.70	1252	25.55	1259	25.42	1265	25.29
33	1: 2.030	1247	25.66	1255	25.50	1262	25.35	1269	25.21	1276	25.08
34	1: 1.940	1256	25.47	1264	25.31	1272	25.15	1279	25.01	1287	24.87
35	1: 1.857	1266	25.28	1274	25.12	1283	24.95	1290	24.80	1298	24.66
36	1: 1.778	1276	25.09	1284	24.91	1293	24.75	1301	24.60	1309	24.45
37	1: 1.703	1285	24.90	1295	24.71	1304	24.55	1312	24.39	1320	24.24
38	1: 1.632	1295	24.70	1305	24.52	1314	24.35	1323	24.19	1332	24.03
39	1: 1.564	1305	24.51	1316	24.32	1326	24.14	1335	23.98	1343	23.82
40	1: 1.500	1316	24.32	1326	24.13	1336	23.95	1346	23.77	1355	23.61
41	1: 1.439	1326	24.13	1337	23.93	1348	23.74	1357	23.57	1367	23.40
42	1: 1.381	1337	23.94	1348	23.73	1359	23.55	1370	23.36	1380	23.19
43	1: 1.326	1348	23.74	1359	23.53	1371	23.34	1382	23.16	1392	22.99
44	1: 1.273	1359	23.55	1372	23.33	1383	23.15	1395	22.95	1405	22.78
45	1: 1.222	1370	23.36	1383	23.14	1395	22.94	1407	22.74	1418	22.57
46	1: 1.174	1381	23.17	1395	22.94	1408	22.73	1420	22.54	1432	22.36
47	1: 1.128	1393	22.98	1407	22.75	1420	22.54	1433	22.33	1445	22.15
48	1: 1.083	1404	22.78	1419	22.55	1433	22.33	1446	22.12	1458	21.94
49	1: 1.041	1416	22.59	1431	22.35	1446	22.13	1460	21.92	1473	21.73
50	1: 1.000	1429	22.39	1444	22.15	1460	21.92	1473	21.71	1487	21.52
51	1: 0.961	1441	22.21	1458	21.96	1473	21.72	1488	21.51	1502	21.31
52	1: 0.923	1453	22.02	1471	21.76	1487	21.52	1502	21.30	1517	21.10
53	1: 0.887	1466	21.82	1484	21.56	1501	21.32	1516	21.10	1532	20.89
54	1: 0.852	1479	21.63	1498	21.36	1515	21.12	1532	20.89	1548	20.68
55	1: 0.809	1493	21.44	1512	21.17	1530	20.92	1547	20.69	1564	20.47
56	1: 0.786	1506	21.25	1526	20.97	1545	20.72	1563	20.48	1580	20.26
57	1: 0.754	1520	21.06	1540	20.77	1560	20.51	1579	20.27	1596	20.05
58	1: 0.724	1534	20.86	1555	20.58	1574	20.31	1595	20.07	1613	19.84
59	1: 0.695	1548	20.67	1572	20.38	1591	20.11	1611	19.86	1629	19.63
60	1: 0.667	1563	20.48	1585	20.18	1607	19.91	1628	19.66	1645	19.42
61	1: 0.639	1577	20.29	1601	19.98	1623	19.71	1645	19.45	1664	19.21
62	1: 0.613	1592	20.10	1617	19.79	1641	19.51	1662	19.25	1683	19.00
63	1: 0.587	1608	19.90	1633	19.59	1657	19.30	1681	19.04	1703	18.79
64	1: 0.563	1623	19.71	1650	19.40	1675	19.10	1698	18.94	1723	18.58
65	1: 0.538	1639	19.52	1667	19.20	1692	18.90	1718	18.73	1742	18.37
66	1: 0.515	1656	19.32	1684	19.00	1711	18.70	1738	18.53	1762	18.16
67	1: 0.493	1672	19.14	1701	18.80	1730	18.50	1757	18.32	1783	17.95
68	1: 0.471	1689	18.94	1719	18.61	1749	18.30	1776	18.11	1803	17.74
69	1: 0.449	1706	18.75	1738	18.41	1768	18.10	1797	17.81	1825	17.53
70	1: 0.429	1724	18.56	1757	18.21	1786	17.90	1818	17.60	1847	17.32

Slime Density Relations.

Per Cent. Solids.	Ratio of Solids to Solution.	Specific Gravity of Pulp and Volume of One Ton in Cubic Feet, for Slimes Containing Solids of Different Specific Gravities.									
		3.00		3.10		3.20		3.30		*4.50	
		S.G.	Vol.	S.G.	Vol.	S.G.	Vol.	S.G.	Vol.	S.G.	Vol.
5	1:19.000	1035	30.93	1035	30.92	1036	30.90	1036	30.89	1040	30.76
6	1:15.667	1042	30.72	1042	30.70	1043	30.68	1043	30.66	1049	30.51
7	1:13.286	1049	30.51	1049	30.48	1050	30.46	1051	30.43	1058	30.26
8	1:11.500	1056	30.30	1057	30.27	1058	30.24	1059	30.21	1067	30.01
9	1:10.111	1064	30.09	1065	30.05	1066	30.02	1067	29.99	1075	29.76
10	1: 9.000	1071	29.87	1072	29.83	1074	29.80	1075	29.77	1084	29.51
11	1: 8.091	1078	29.65	1080	29.61	1082	29.58	1083	29.54	1093	29.26
12	1: 7.333	1087	29.44	1088	29.40	1090	29.36	1091	29.32	1102	29.01
13	1: 6.692	1095	29.23	1096	29.18	1098	29.14	1099	29.10	1112	28.76
14	1: 6.144	1103	29.01	1105	28.96	1106	28.92	1108	28.88	1122	28.52
15	1: 5.667	1111	28.80	1113	28.74	1115	28.70	1117	28.66	1132	28.27
16	1: 5.250	1119	28.59	1122	28.53	1124	28.48	1125	28.43	1142	28.02
17	1: 4.882	1128	28.37	1130	28.31	1132	28.26	1134	28.21	1152	27.77
18	1: 4.556	1136	28.16	1139	28.10	1141	28.04	1143	27.99	1163	27.52
19	1: 4.263	1145	27.95	1148	27.88	1150	27.82	1153	27.76	1173	27.27
20	1: 4.000	1154	27.73	1157	27.66	1159	27.60	1162	27.54	1184	27.02
21	1: 3.762	1163	27.52	1166	27.44	1169	27.38	1171	27.32	1194	26.77
22	1: 3.545	1172	27.31	1175	27.23	1178	27.16	1181	27.09	1206	26.52
23	1: 3.348	1181	27.09	1184	27.01	1188	26.94	1191	26.87	1218	26.28
24	1: 3.167	1190	26.88	1194	26.79	1198	26.72	1201	26.65	1230	26.03
25	1: 3.000	1200	26.67	1204	26.58	1208	26.50	1211	26.42	1241	25.78
26	1: 2.846	1210	26.45	1214	26.37	1218	26.28	1222	26.20	1253	25.53
27	1: 2.704	1220	26.24	1224	26.15	1228	26.06	1232	25.98	1266	25.28
28	1: 2.571	1230	26.03	1234	25.93	1239	25.84	1242	25.75	1278	25.03
29	1: 2.448	1240	25.81	1244	25.71	1249	25.62	1253	25.53	1291	24.78
30	1: 2.333	1250	25.60	1255	25.50	1260	25.40	1264	25.31	1304	24.53
31	1: 2.226	1261	25.39	1266	25.28	1271	25.18	1275	25.08	1317	24.28
32	1: 2.125	1271	25.17	1277	25.06	1282	24.96	1287	24.86	1331	24.04
33	1: 2.030	1282	24.96	1288	24.85	1293	24.74	1299	24.64	1345	23.79
34	1: 1.940	1293	24.75	1299	24.63	1305	24.52	1311	24.41	1359	23.54
35	1: 1.857	1304	24.53	1310	24.41	1317	24.30	1323	24.19	1374	23.29
36	1: 1.778	1316	24.32	1322	24.19	1329	24.08	1335	23.97	1389	23.04
37	1: 1.703	1328	24.11	1334	23.98	1341	23.86	1347	23.75	1404	22.79
38	1: 1.632	1340	23.89	1346	23.76	1353	23.64	1360	23.52	1420	22.54
39	1: 1.564	1351	23.68	1358	23.55	1366	23.42	1373	23.30	1435	22.29
40	1: 1.500	1363	23.47	1371	23.33	1379	23.20	1387	23.08	1451	22.04
41	1: 1.439	1376	23.26	1384	23.11	1393	22.98	1400	22.85	1468	21.79
42	1: 1.381	1389	23.04	1397	22.89	1406	22.76	1414	22.63	1485	21.55
43	1: 1.326	1402	22.83	1411	22.68	1419	22.54	1428	22.41	1502	21.30
44	1: 1.273	1415	22.61	1425	22.46	1433	22.32	1442	22.18	1519	21.05
45	1: 1.222	1429	22.40	1438	22.24	1447	22.10	1456	21.96	1538	20.80
46	1: 1.174	1443	22.19	1452	22.02	1462	21.88	1471	21.74	1557	20.55
47	1: 1.128	1457	21.97	1467	21.81	1477	21.66	1487	21.51	1576	20.30
48	1: 1.083	1471	21.76	1483	21.60	1493	21.44	1503	21.29	1595	20.05
49	1: 1.041	1485	21.55	1497	21.38	1508	21.22	1519	21.07	1615	19.81
50	1: 1.000	1500	21.33	1512	21.16	1524	21.00	1535	20.85	1637	19.56
51	1: 0.961	1515	21.12	1528	20.94	1540	20.78	1551	20.62	1658	19.31
52	1: 0.923	1531	20.91	1544	20.73	1556	20.56	1568	20.40	1679	19.06
53	1: 0.887	1547	20.69	1560	20.51	1573	20.34	1585	20.18	1700	18.81
54	1: 0.852	1563	20.48	1577	20.29	1590	20.12	1603	19.96	1724	18.56
55	1: 0.809	1579	20.27	1594	20.08	1608	19.90	1621	19.73	1748	18.31
56	1: 0.786	1596	20.05	1611	19.87	1626	19.68	1640	19.51	1772	18.06
57	1: 0.754	1613	19.84	1628	19.65	1645	19.46	1659	19.29	1796	17.81
58	1: 0.724	1631	19.63	1646	19.43	1663	19.24	1678	19.06	1822	17.56
59	1: 0.695	1649	19.41	1665	19.21	1682	19.02	1697	18.84	1848	17.32
60	1: 0.667	1667	19.20	1684	19.00	1702	18.80	1718	18.62	1875	17.07
61	1: 0.639	1686	18.99	1704	18.78	1722	18.58	1739	18.39	1903	16.82
62	1: 0.613	1705	18.77	1724	18.56	1742	18.36	1761	18.17	1932	16.57
63	1: 0.587	1724	18.56	1745	18.34	1764	18.14	1783	17.95	1961	16.32
64	1: 0.563	1745	18.35	1765	18.12	1786	17.92	1805	17.72	1992	16.07
65	1: 0.538	1765	18.13	1786	17.91	1808	17.70	1828	17.50	2023	15.82
66	1: 0.515	1786	17.92	1808	17.69	1830	17.48	1852	17.28	2054	15.57
67	1: 0.493	1808	17.71	1831	17.47	1853	17.26	1876	17.06	2088	15.32
68	1: 0.471	1830	17.49	1854	17.26	1877	17.04	1901	16.83	2123	15.08
69	1: 0.449	1852	17.28	1878	17.04	1902	16.82	1927	16.61	2159	14.83
70	1: 0.429	1875	17.07	1902	16.83	1926	16.60	1953	16.39	2195	14.58

* 80 per cent pyrite and 20 per cent. quartz.

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